

AIDS TO ANATOMY (POCKET ANATOMY)

by

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PREFACE TO THE TWELFTH EDITION

THE first edition of "Aids to Anatomy" appeared in 1876, a book of 64 pages. The publication of eleven further editions is an indication of the popularity of the book with succeeding generations of medical students.

In preparing this edition I have retained the original plan, which is to provide an abstract of the larger textbooks which cover human anatomy *system by system*. I have included much new material: the broncho-pulmonary segments, the conducting system of the heart, the cerebral ventricles, and many other things too numerous to mention here. Countless adjustments have been made and 13 new illustrations are added. While still retaining most of the old names (for continuity during a period of transition) the new international nomenclature has been adopted, and where appropriate both new and old names are in the index.

This little book has been in use for nearly 90 years, and I hope the new edition will serve still better the needs of present-day students.

R. J. LAST.

CONTENTS

	PAGE
PREFACE TO THE TWELFTH EDITION -	v
CHAP.	
I. THE JOINTS - - - -	I
II. THE MUSCLES - - - -	42
III. THE VASCULAR SYSTEM - -	121
IV. THE VEINS - - - -	179
V. THE LYMPHATIC SYSTEM - -	195
VI. THE NERVOUS SYSTEM - -	204
VII. THE NERVES - - - -	240
VIII. THE SENSE ORGANS - -	306
IX. THE ORGANS OF DIGESTION - -	319
X. THE RESPIRATORY SYSTEM - -	351
XI. THE URINARY ORGANS - -	369
XII. THE MALE GENITAL ORGANS - -	374
XIII. THE FEMALE GENITAL ORGANS - -	381
XIV. THE DUCTLESS GLANDS - -	387
INDEX - - - -	391

The Joints

A JOINT is the arrangement whereby separate bones or cartilages are attached to each other. The different kinds of joints can be classified either structurally or functionally.

STRUCTURAL CLASSIFICATION (Fig. 1)

(1) **Fibrous joints:** The articulating surfaces are attached by fibrous tissue continuous with the periosteum or perichondrium. Movement varies from nil (*e.g.* sutures of skull) to a wide range (*e.g.* interosseous membrane of forearm).

(2) **Cartilaginous joints:**

(a) **Primary cartilaginous:** Bone and cartilage blend (*e.g.* all epiphyses). There is no movement at all.

(b) **Secondary cartilaginous** (also called symphysis): Occurs only between bones. Each articulating bone surface is coated with hyaline cartilage. The two cartilage plates are united by fibrous tissue which often contains a cavity. The cavity contains either lymph (*e.g.* symphysis pubis, manubrio-sternal joint) or a gel (intervertebral disc). It never contains synovial fluid. Slight movement is allowed.

(3) **Synovial joints:** Free surfaces covered with hyaline cartilage (except clavicle and mandible). Enclosed in fibrous-tissue capsule. Capsule and all non-articulating surfaces lined by synovial membrane. Cavity contains a viscous *synovial fluid* secreted by the membrane. Movement varies from nil (*e.g.*

THE JOINTS

sacro-iliac joint) through a variety of types (hinge, pivot, gliding, ball and socket, etc.) to great freedom (e.g. shoulder, hip).

FUNCTIONAL CLASSIFICATION

Freely movable joints -- most diarthroses.

Slightly movable joints -- amphiarthroses or symphyses (These are permanent joints of movement.)

Immovable joints -- sutures and synchondroses. (These are temporary joints of growth.)

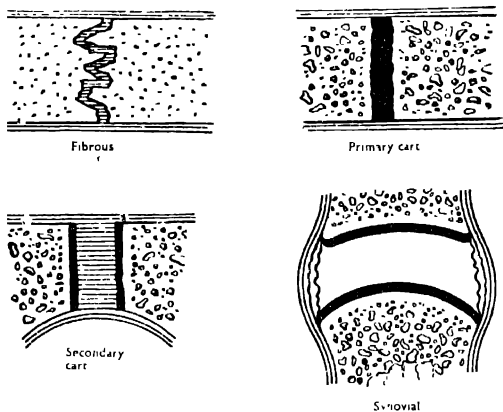


FIG. 1.-- THE STRUCTURAL CLASSIFICATION OF JOINTS.

Hyaline cartilage is shown in heavy black.

In describing a joint the following systematic order is recommended:

- (1) Definition, purpose and class.
- (2) Articulating surfaces.
- (3) Connecting structures: synovial membrane, if any.
- (4) Nerve and blood supply.

DEVELOPMENT

- (5) Movements and mechanism.
- (6) Stability. Factors are (a) bony, (b) ligamentous, (c) muscular.
- (7) Important relations.
- (8) Applied anatomy.

DEVELOPMENT OF JOINTS

Condensations of mesoderm may ossify direct (ossification in membrane—*e.g.* flat bones of skull, clavicle) or may chondrify first (ossification in cartilage—*e.g.* base of skull, long bones generally). Mesoderm between bones produces joint structures. Joint cavity results from disappearance of mesoderm. Perichondrium persists across joint cavity as capsule, lined with synovial membrane.

BLOOD SUPPLY OF JOINTS

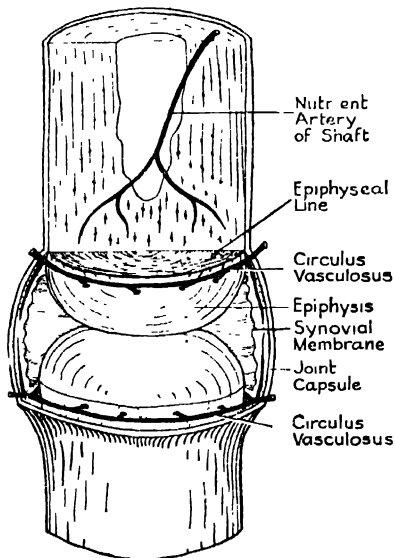


FIG. 2.—SCHEME OF BLOOD SUPPLY TO A JOINT.

The nutrient artery is an end artery. The circulus vasculosus is a plexus of fine vessels between capsule and synovial membrane.

THE JOINTS

Nutrient artery of shaft supplies down to epiphyseal cartilage—end arteries, subject to embolism and infarction (osteomyelitis in children common on shaft side of epiphyseal plate). Epiphysis and capsule supplied by *circulus vasculosus* of William Hunter, lying between attachments of capsule and synovial membrane (Fig. 2). No anastomosis between *circulus vasculosus* and nutrient artery of shaft until ossification of epiphyseal plate of cartilage at completion of growth (osteomyelitis in adult may affect any part of bone).

NERVE SUPPLY OF JOINTS

Motor nerve to a muscle commonly gives branch to supply joint on which the muscle acts, and skin over joint (Hilton's Law).

THE JOINTS OF THE VERTEBRAL COLUMN

Before birth whole column is concave forwards (primary curve). After birth neck straightens with head movements and lumbar region with standing (the two forward convexities are called secondary curves). Thorax and sacrum retain primary curves.

The bodies of the vertebrae are united to one another by intervertebral discs which yield sufficiently to allow slight bending and twisting of the column. This involves movement between the arches, so that there are small diarthrodial joints on each side between each pair of arches.

1. — JOINTS OF THE BODIES—SYMPHYSES (See Fig. 5, p. 10).

The articulating surfaces are flat, except in the neck, where their edges are reciprocally bevelled and lipped for tiny synovial joints (Fig. 3).

Intervertebral disc: The vertebral body is surfaced by a plate of hyaline cartilage. The *anulus fibrosus*, uniting adjacent plates, is made of concentric layers of fibrous tissue. In each layer the fibres slope parallel at 45 degrees, alternating at right angles

VERTEBRAL COLUMN

throughout adjacent layers of the anulus. Slightly posterior to true centre of anulus is a gel, the *nucleus pulposus*, a remnant of the notochord. The gel resists loss of volume by pressure of body weight, and centrifugal thrust of nucleus tends to stretch fibres of anulus.

Backward displacement of the nucleus pulposus or of injured disc tissue, causing pressure on the spinal cord or nerves, is a recognised clinical entity.

The ligaments are anterior and posterior, the more superficial fibres forming a continuous band—the **anterior longitudinal ligament** extending from anterior arch of atlas down to the sacrum, and the **posterior longitudinal ligament** from the body of the axis to the sacrum. Anterior longitudinal ligament broadens from above down and is adherent to periosteum of each vertebral body. Posterior longitudinal ligament is attached more firmly to discs than to vertebrae, and is wider opposite discs than opposite vertebrae.

2. JOINTS OF THE ARCHES

These are gliding diarthrodial joints between the inferior articular processes of the vertebra above ("upper facets") and the superior articular processes of the vertebra below ("lower facets").

The facets are arranged as follows (Fig. 3):

<i>Region.</i>	<i>Shape and Direction.</i>	<i>Movement Allowed</i>
Cervical.	Flat. In same plane.	Flexion and extension.
	Upper facet: downwards and forwards Lower facet: upwards and backwards.	Lateral flexion.
Thoracic.	Flat. On arc of circle	Flexion and extension.
	Upper facet: forwards. Lower facet: backwards.	Rotation. Slight lateral flexion
Lumbar.	Upper convex: faces laterally.	Flexion and extension
	Lower concave: faces medially.	and lateral flexion giving circumduction of column as a whole.

Note on movements. Head nodding and rotation occur at atlanto-occipital and atlanto-axial joints

THE JOINTS

(q.v.). Elsewhere in column flexion-extension and lateral flexion are possible in all regions (range of each varies with region). Pure rotation possible only in thorax (limited by splinting effect of ribs). Lateral flexion in neck and thorax (not in lumbar region) accompanied by secondary rotation; upper facet glides down *and back* on concave side, glides up *and forward* on convex side. So tip of spinous process rotates towards lateral convexity of curve (seen in scoliosis).

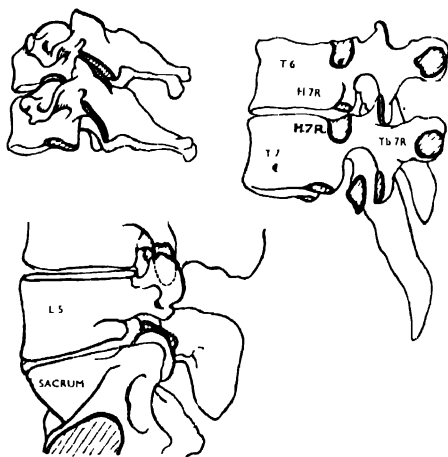


FIG. 3.—TYPICAL CERVICAL, THORACIC AND LUMBAR VERTEBRAL ARTICULATIONS (SEE TABLE p. 5).

Ligaments connecting the arches:

- (1) Capsular ligaments of the above joints.
- (2) The laminae are connected by the **ligamenta flava**—thick, longitudinal, elastic bands attached above to the anterior aspect of the lower border of a lamina, and below to the posterior aspect of the upper border.

(3) The spines are connected by weak *interspinous ligaments*, and their tips by stronger **supraspinous ligaments**. In the neck, the *ligamentum nuchæ* is a modification of these. It is not a stout elastic band in man, as it is in some quadrupeds, but is a thin sickle-shaped *intermuscular septum* attached above to the occipital crest, below to the spine of the 7th cervical vertebra. Its deep edge reaches the spines of the other cervical vertebrae; its superficial edge reaches the investing fascia between the posterior neck muscles.

(4) **Intertransverse ligaments**: These are weak and thin, and connect the transverse processes; they are paired on each side.

3.—SPECIAL JOINTS CONCERNED WITH MOVEMENTS OF THE HEAD

The 1st cervical vertebra articulates above with the occipital bone, and the joints between the atlas and axis are greatly modified to allow rotation of the head. These joints are in series with the lateral joints between the bodies of the cervical vertebrae (p. 4), not with the arch-joints of other vertebrae. The 1st and 2nd cervical nerves come out behind them.

Joints between the head and the vertebral column—

The atlanto-occipital joints (Fig. 4).—The articular surfaces are the upper, reniform, concave surface of the lateral mass of the atlas, and the convex occipital condyles. They are connected by a capsule. The anterior and posterior arches of the atlas are connected to the margins of the foramen magnum by the anterior and posterior atlanto-occipital membranes. The lower edge of the posterior atlanto-occipital membrane arches across the groove on the posterior arch of the atlas to allow the vertebral artery to enter the vertebral canal and the 1st nerve to come out.

Movements: Flexion and extension. Lateral flexion. No rotation.

The stability of the atlanto-occipital joints depends on the skull being held down by ligaments connecting

THE JOINTS

the skull to the axis, and by short muscles surrounding the joints (see p. 64 and Fig. 25).

The atlanto-axial joints (Fig. 4):

(1) The transverse ligament of the atlas, attached to tubercles on the medial aspect of the lateral masses, shuts off a small anterior compartment for

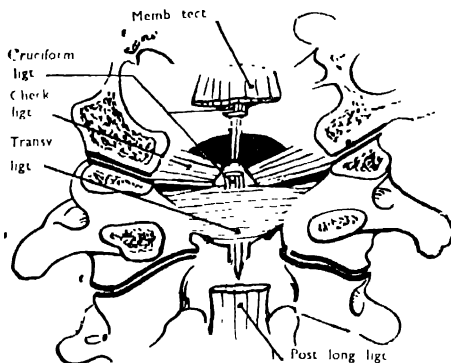


FIG. 4.—LIGAMENTS CONNECTING THE SKULL TO THE
ATLAS AND AXIS.

The arches of the vertebræ and the occipital bone down to the condyles have been cut away, and the brain and cord removed.

the dens from a larger posterior containing the spinal cord.

(2) The dens projects into the anterior compartment, and has a smooth cartilaginous surface in front to form a synovial joint with a facet on the back of the anterior arch of the atlas; similarly the dens is cartilage-covered behind, to articulate with the front of the transverse ligament, by an intervening bursa.

(3) At the junction of pedicle with body the axis has a large oval facet facing upwards and slightly outwards. The under surface of the lateral mass

of the atlas has a similar facet articulating with this by a synovial joint.

Movements: When the atlas rotates, carrying with it the head, the lateral mass slides forwards and backwards at this joint.

Running downwards and inwards from the back of the lateral mass to the back of the body of the axis is a thin but strong accessory atlanto-axial ligament.

(4) Other ligaments connecting the skull to the axis:

- (a) The **apical ligament** from the tip of the dens to the anterior margin of the foramen magnum (remnant of the notochord).
- (b) The strong **alar (check) ligaments** connecting the sides of the dens to the medial aspect of the occipital condyles
- (c) A band stretching up from the back of the body of the axis to the transverse ligament, and thence to the foramen magnum. These with the transverse ligament form the **cruciform (cruciate) ligament**, of which they are the upper and lower crura.
- (d) The **membrana tectoria** is a broad band separating the cruciform ligament from the dura mater of the spinal cord—attached to the body of the axis with the posterior longitudinal ligament. Above it enters the skull through the foramen magnum, to fuse with the periosteum of the basi-occiput. The spinal dura mater is adherent to the membrana tectoria.

LUMBO-SACRAL JOINT

The lower surface of the 5th lumbar vertebra slopes downwards and forwards, its body being a wedge, narrow behind; this wedge supports the whole weight of trunk above, and has a tendency to slip forwards (spondylolisthesis), prevented by the transverse direction of the articular facets, the intervertebral disc and the strong ilio-lumbar ligaments.

Nerve supply of vertebral joints: They are supplied by branches of the corresponding spinal nerves, *which pass out close to the joints.*

THE JOINTS OF THE RIBS (Fig 5)

A typical rib articulates behind by its head and by its tubercle with the vertebral column; anteriorly the first seven costal cartilages articulate with the sternum, and the 8th, 9th and 10th with the costal cartilage above. The junction of the rib with its costal cartilage represents the failure of the ossification process to extend all the way round, a synchondrosis resulting.

JOINTS OF THE HEADS OF THE RIBS (SYNOVIAL)

From the 2nd to the 9th, the head articulates with facets on the upper border of the corresponding

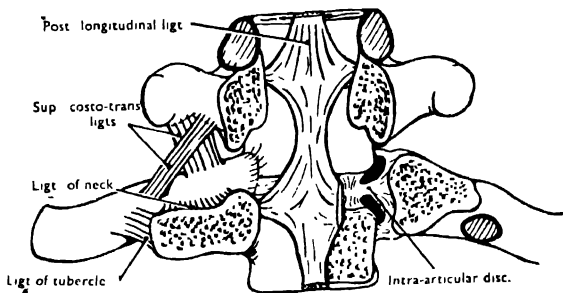


FIG. 5.—SHOWING LIGAMENTS CONNECTING RIB TO TRANSVERSE PROCESS OF VERTEBRA, JOINT CAVITY OF HEAD OF RIB AND (BY REMOVAL OF ARCHES AND SPINAL CORD) THE POSTERIOR LONGITUDINAL LIGAMENT.

vertebral body and the lower border of the vertebra above. Between the two a ridge on the head of the

rib is attached to the edge of the intervertebral disc by an **intra-articular ligament**. The anterior part of the capsule of the joint is reinforced by a **triradiate ligament**, whose central limb crosses the midline forming the hypochondral bar. The first and the lower three ribs have a simple joint—each with its own vertebral body.

JOINTS OF THE TUBERCLES OF THE RIBS (SYNOVIAL)

The medial facet of the tubercle articulates with a facet on the front of the tip of the corresponding transverse process, except the last two ribs.

Accessory ligaments (costo-transverse ligaments):

(a) Connecting the rib to the transverse process of the corresponding vertebra are:

The **costo-transverse ligament**—from the back of the neck of the rib to the front of the transverse process (also called **ligament of neck**).

The **lateral costo-transverse ligament**—from the lateral facet of the tubercle to the tip of the transverse process.

(b) To the transverse process above.

The **superior**—consisting of two bands, anterior and posterior, from the upper edge of the neck to the lower border of transverse process above.

Movements: The raising of the shaft of the rib by the intercostal muscles results in a gliding movement in both the joint of the head and that of the tubercle. The neck rotates around its own long axis.

COSTO-CHONDRAL JOINTS

All these are primary cartilaginous joints, permitting no movement.

JOINTS OF THE COSTAL CARTILAGES WITH THE STERNUM

First costal cartilage fixed by synchondrosis to manubrium; the two move as one, hence persistence

throughout life, of the movable joint between manubrium and body of sternum. Rigidity of first costal cartilage essential for attachment of costo-clavicular ligament, to stabilize clavicle (p. 16) and thus whole of upper limb.

Segments of sternum (sternebræ) ossify separately. Costal cartilage articulates with upper and lower edges of adjacent sternebræ by synovial joint, divided into upper and lower compartments by small intra-articular ligament. As sternum ossifies, fusion of adjacent sternebræ is accompanied by disappearance of intra-articular ligament. Hence in adult chondro-sternal synovial joints are single cavities except second, where intra-articular ligament persists.

SUMMARY

First chondro-sternal articulation non-synovial throughout life. Second a bilocular synovial cavity throughout life. Third to seventh synovial cavities bilocular in infancy, unilocular after ossification of gladiolus is complete in adolescence, and tend to become obliterated in old age. Tips of 8th, 9th and 10th costal cartilages form synovial joints, each with costal cartilage above it.

JOINTS OF THE STERNEBRÆ

These are cartilaginous joints which disappear from below upwards up to early adult life. The joint between the manubrium and gladiolus, however, persists throughout life. It is a secondary cartilaginous joint, and moves during respiration.

MOVEMENTS OF THE THORAX IN RESPIRATION

The ribs are pulled up by the intercostal muscles and, because of their curves, increase the transverse diameter of the chest; also, since they are directed obliquely downwards, the raising of them increases the antero-posterior diameter of the chest—pushing the

sternum forwards. This is the “**pump-handle**” movement. Towards the end of deep inspiration diaphragm pulls up and everts ribs of the costal margin; this is the “**bucket-handle**” movement.

THE MANDIBULAR JOINT (TEMPORO-MANDIBULAR JOINT)

(Fig. 6, and see Fig. 21, p. 52)

A joint between the head of the mandible and the mandibular fossa and eminence on the under surface of the temporal bone. It has a double joint cavity designed to allow the head to glide on the base of the skull and also to hinge round its long axis.

Articulating surfaces:

Head of mandible has its long axis directed backwards and medially, and is covered by fibro-cartilage which extends well down back of condyle.

Mandibular fossa of temporal bone is formed entirely by squama of temporal. The concave anterior surface of the tympanic plate looks like part of the articular surface, but is occupied by parotid gland (see Fig. 6). The articular eminence is covered with fibro-cartilage, and is within the joint.

The **capsule** is loose. Its upper limit is attached posteriorly to the squamo-tympanic and petrosquamous sutures, and anteriorly to just in front of the articular eminence. Below, the capsule is attached along the articular margin of the head of the mandible, and is strengthened laterally by the *lateral (temporo-mandibular) ligament*, whose fibres are directed from the glenoid tubercle downwards and backwards to the neck of the mandible.

The **articular disc**, adapted to the bony surfaces, is attached all round to the capsule; it receives anteriorly fibres of the lateral pterygoid muscle.

Accessory ligaments: Two bands are usually described as additional ligaments of this joint.

Spheno-mandibular ligament: A flat band from spine of sphenoid to lingula and lower margin of mandibular foramen.

Stylo-mandibular ligament: Fascial band from styloid process to posterior border of ramus.

NOTE—The spheno-mandibular ligament is a part of the embryonic mandibular (or 1st visceral) arch. This arch is completed by anterior ligament of malleus, malleus and incus above, and by Meckle's

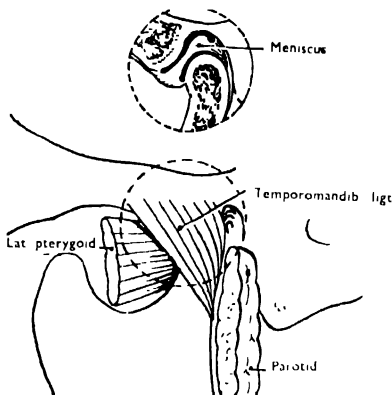


FIG. 6.—THE LEFT TEMPORO-MANDIBULAR JOINT SEEN FROM THE SIDE.

Note the direction of fibres of lateral (temporo-mandibular) ligament. Inset: the joint opened to show the meniscus.

cartilage below. Note also that the maxillary vessels, auriculo-temporal nerve and fibres of lateral pterygoid muscle separate the ligament from the mandible, but the chorda tympani nerve lies deep to the ligament.

Nerve supply: A relatively large branch from the auriculo-temporal (mandibular division of 5th nerve) with a small contribution from the nerve to the masseter (Hilton's Law).

Movements: The mandible (head and disc together) is protruded by the lateral pterygoid and retruded by the posterior fibres of temporalis. The mouth is opened by the lateral pterygoid muscles, which pull the head and disc forwards on to the articular

UPPER EXTREMITY

eminence, and by the digastric muscle, which retracts and depresses the chin, aided by gravity.

The mandible is pulled up again by the combined actions of the temporalis, masseter and medial pterygoid muscles (Fig. 21).

Side-to-side movements are produced by unilateral action of the pterygoids.

NOTE.—The ramus of the mandible moves round a transverse axis between the two lingulae. (This can be confirmed by finding an immobile point in one's own jaw, about half-way down the ramus.) This point being immobile, the inferior dental nerve is not stretched during opening of the jaw.

The advantage of the gliding mechanism in contrast with a hinge-joint is that it gives some degree of parallelism of the open jaws and allows grinding movements. It has the disadvantage that the condyle may slip beyond the articular eminence and become fixed below the zygomatic arch (dislocation).

THE JOINTS OF THE UPPER EXTREMITY

STERNO-CLAVICULAR JOINT (Fig. 7)

A gliding synovial joint allowing little movement; this little movement, however, is translated into free movement of the outer end of the clavicle.

Articulating surfaces: These are three, the medial end of the clavicle articulating with the manubrium sterni and with the upper surface of the first costal cartilage.

The angle of the manubrium sterni shows a shallow cartilage-covered notch. The medial end of the clavicle, surfaced by fibro-cartilage, is enlarged and prominent. It rests partly on this notch and partly on the first costal cartilage. There is no adaptation of the articular surfaces to one another.

Connecting structures: In addition to the capsule, there are anterior and posterior ligaments and a superior ligament. The superior ligament is very strong and stretches across to blend with the similar ligament of the opposite side (interclavicular

ligament). Outside the capsule the medial end of the clavicle is firmly bound down to the first costal cartilage by the thick **costo-clavicular (rhomboid) ligament**.

The joint is subdivided by an **intra-articular disc** which, in addition to being attached by its periphery to the capsule, is attached below to the costal

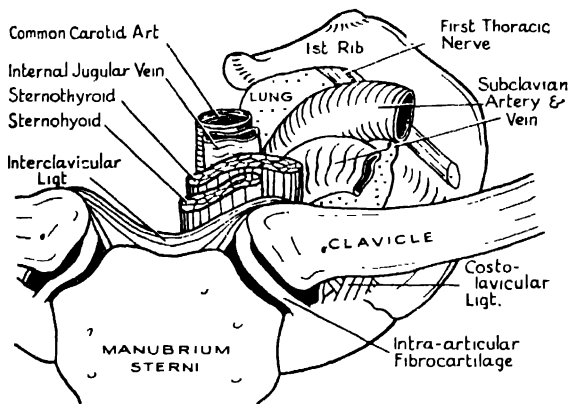


FIG. 7.—THE POSTERIOR RELATIONS OF THE STERNO-CLAVICULAR JOINT.

The joint has been opened to show the intra-articular fibrocartilage.

cartilage and above to the clavicle. Synovial membrane lines the capsule of each compartment of the joint.

Nerve supply: Suprasternal cutaneous nerve (C. 3, 4).

Movements: By allowing slight gliding, the joint allows the lateral end of the clavicle (hence the arm) to sweep through wide arcs especially in the vertical plane. 'Clavicular' movement is induced passively by scapular movement (p. 20). In vertical and horizontal planes medial end of clavicle moves around

costo-clavicular ligament in opposite direction to lateral end, like a very asymmetrical see-saw. Clavicle also rotates (up to 40 degrees) around its long axis in abduction of arm.

Stability: Medial end of clavicle prevented from over-elevation by downward pull of disc and inter-clavicular ligament. Medial thrust from elbow or hand resisted by costo-clavicular ligament, which is stronger than clavicle itself (clavicle fractures before ligament ruptures).

Posterior relations: Immediately behind the joint are the great vessels of the neck—namely, the left innominate vein and left common carotid artery, and on the right side the bifurcation of the innominate artery; between the vessels and the joint are the thin sterno-thyroid and sterno-hyoid muscles.

Behind the joint and the vessels is the anterior border of the pleura.

ACROMIO-CLAVICULAR JOINT

This is a synovial joint allowing a limited amount of gliding movement.

Articulating structures : Flat facet on clavicle faces downwards and laterally. Flat facet on acromion faces upwards and medially. The clavicle therefore overlaps the acromion process.

Connecting structures : Simple capsule thickened above.

Coraco-clavicular ligament (*conoid and trapezoid ligaments*) is an accessory ligament of this joint. Conoid ligament, apex downwards, connects conoid tubercle of coracoid process to that of clavicle; helps muscles to resist downward pull of scapula and attached upper limb. Trapezoid ligament directed nearly horizontally outwards from top of coracoid to trapezoid ridge on clavicle. Takes medial thrust of scapula from humerus to clavicle.

The joint also has an imperfect **intra-articular disc**.

Nerve supply: Supra-acromial nerves (C 3, 4).

Movements: Induced passively by scapular movement. Axis of movement is coraco-clavicular ligament.

(1) When arm is raised above shoulder, scapula

rotates on clavicle so as to make glenoid fossa face upwards.

(2) As arm moves forwards body of scapula clings to chest wall, which involves diminution of angle between coracoid and clavicle, allowed by gliding of joint surfaces.

NOTE.—(1) This joint is subcutaneous and readily palpable.

(2) Upward dislocation of outer end of clavicle is readily reduced, but will not remain reduced owing to inclination of surfaces.

SHOULDER-JOINT (Fig. 8)

This is a synovial "ball-and-socket" joint, allowing very free movement between the humerus and the scapula.

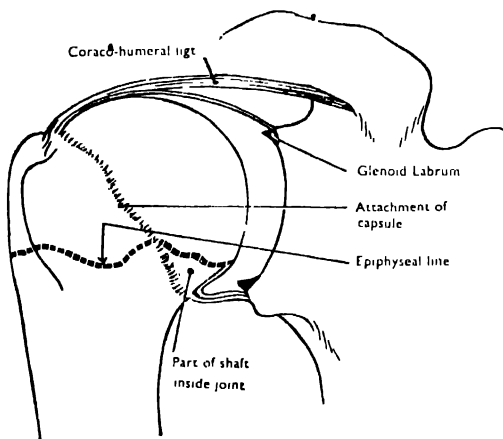


FIG. 8.—DIAGRAM OF THE SHOULDER-JOINT OPENED TO SHOW THAT THE EPIPHYSEAL LINE OF THE HUMERUS IS PARTLY WITHIN THE CAPSULE AND PARTLY OUTSIDE IT.

Note that the coraco-humeral ligament does not arise from the root of the coracoid process.

Articulating structures : Head of humerus forms nearly half a sphere; directed medially, upwards and backwards.

Glenoid fossa of scapula is slightly concave and pear-shaped. It is much smaller than the head of the humerus. With the arm hanging naturally it faces forwards as well as laterally. It is deepened slightly by a rim of fibro-cartilage—the **glenoidal labrum**. Developmentally it includes part of the coracoid.

The socket is guarded above by the **coraco-acromial ligament**, which with the two processes forms the **coraco-acromial arch**. The **coraco-acromial ligament** is flat and triangular; its wide end is attached to the lateral border of the coracoid process, its apex to the acromion in front of the clavicular facet.

Connecting structures : The **capsule** is very loose. It is attached to the scapula outside the glenoidal labrum, and to the humerus around the anatomical neck, except that it extends about 1 inch down the shaft on the medial aspect. It bridges across the top of the intertubercular sulcus, and it is perforated in front by the subscapularis bursa.

The epiphyseal line of the humerus is extracapsular, except the small medial part where the capsule extends down the shaft (Fig. 8).

The **synovial membrane** lines the capsule; communicates with the subscapularis bursa; encloses the biceps tendon and passes out along the tendon under the transverse ligament; and covers the small area of shaft within the joint.

Special ligaments : (1) **Coraco-humeral :** From the coracoid process to the neck of the humerus above the great tuberosity.

(2) **Gleno-humeral :** Three thickenings within capsule on its anterior aspect—upper, middle and lower.

(3) **Tendon of long head of biceps :** Passes (within the capsule) from the supraglenoid tubercle across the top of the joint to the bicipital groove.

(4) **Tendons** of spinati, subscapularis and teres minor are partly attached into capsule, which they strengthen above, in front and behind. Capsule with

fused tendons is called "rotator cuff." Rotator cuff plays below coraco-acromial arch, lubricated by sub-acromial bursa.

Nerves. enter the joint from the suprascapular; circumflex and subscapular (Hilton's Law, p. 4).

Arteries enter from the suprascapular and anterior and posterior circumflex.

Movements: *All but very slight gleno-humeral movement always accompanied by movements of scapula on clavicle and of clavicle on manubrium.* Shoulder joint and both clavicular joints make a chain of three joints forming a "thoraco-humeral" articulation. Movements in each joint should be analysed separately, although they occur simultaneously.

Movement at shoulder joint. Very free; limited by available surface of head of humerus (check on dry bones) and by tension in soft parts. Flexion in sagittal plane up to almost full abduction. Extension limited to 45 degrees or less. Abduction in coronal plane to only 90 degrees unless humerus rotates laterally, when abduction possible up to 120 degrees. (Repeat for emphasis, *these movements always accompanied by movements of scapula and of clavicle.*) Medial and lateral rotation around long axis of humerus limited by available articular surface.

Movements of scapula. Protraction (as in reaching forwards) produced by serratus anterior and pectorals. Retraction by trapezius with rhomboids. Rotation produced by trapezius and last four digitations of serratus anterior (Fig. 26). In raising arm to 180 degrees, 120 degrees occurs at shoulder joint, 20 degrees by rotation of scapula on clavicle, and 40 degrees by rotation of clavicle around its long axis.

Stability: (1) *Bony factors.* Deepening of fossa by glenoid labrum. (2) *Ligamentous factors.* Coraco-acromial ligament prevents upward dislocation. (3) *Muscular factors.* Pull of muscles of rotator cuff holds humeral head in glenoid cavity. Long head of triceps acts as a strap below the joint in full abduction.

THE ELBOW-JOINT (Fig. 9)

This is a hinge-joint between the lower end of the

humerus and the ulna and radius. Its cavity and some of its ligaments are common to it and the superior radio-ulnar joint, but the latter is described separately because of its entirely different movement.

Articular structures : The trochlear notch of the ulna embraces the trochlea of the humerus; the slightly concave circular upper surface of the head of the radius articulates with the convex capitulum of the humerus.

Connecting structures :

Capsule is very thin in front and behind, and is attached to the humerus above the coronoid and radial fossæ in front and to the margins of the large olecranon fossa behind. Distally it is attached to the margins of the trochlea of the ulna and to the annular ligament of the superior radio-ulnar joint.

The epiphyseal line of the humerus is almost entirely intracapsular; that of the ulna extracapsular, and of the radius intracapsular.

Collateral ligaments : **Medial ligament** is triangular in shape; attached proximally to the medial epicondyle, distally to the medial margins of the coronoid and olecranon processes. Its distal edge is thickened, forming the transverse band, under which the posterior recurrent ulnar artery and a branch of the ulnar nerve enter the joint.

Lateral ligament runs from the lateral epicondyle to the annular ligament (it is not attached to the head of the radius, so as to allow this to rotate freely in pronation and supination).

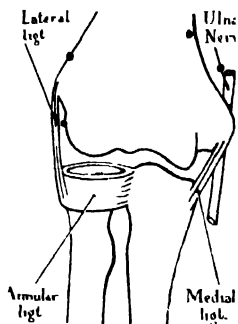


FIG. 9.—DIAGRAM OF ELBOW-JOINT OPENED FROM FRONT.

Note that the lateral ligament is attached below to the annular ligament—not to bone.

Synovial membrane covers the floors of the olecranon, radial and coronoid fossæ, and extends into the superior radio-ulnar joint, lining the annular ligament.

Nerve Supply: From musculo-cutaneous, median, radial and ulnar (Hilton's Law).

Blood Supply: From anastomosis around elbow-joint (profunda brachii, ulnar collateral, supra-trochlear, radial, ulnar and interosseous recurrent).

Movements: Flexion and extension only.

NOTE.—"Carrying" angle open laterally, due to medial part of lower end of humerus being lower than lateral. Matched by equal and opposite carrying angle at the wrist. Carrying angle of elbow obvious if extended forearm is supinated, disappears in pronation (the "working position") to bring axes of arm and forearm into line.

Important relations: The joint is deeply placed, being covered by the thick triceps tendon behind, and by brachialis and brachio-radialis in front. The ulnar nerve lying on the medial epicondyle is in contact with the medial ligament.

RADIO-ULNAR JOINTS

The head of the radius rotates in the radial notch at the superior joint; the lower end of the radius slides round the head of the ulna at the inferior joint. The interosseous membrane constitutes the "middle joint."

Superior joint: The **annular ligament** (Fig. 9) is attached to the anterior and posterior margins of the radial notch of the ulna, and encircles the head of the radius. Its lower edge forms a smaller ring than its upper, so that the head of the radius cannot readily be pulled out from its grasp.

The **synovial membrane**, continuous with that of the elbow-joint, is attached to the neck of the radius but bulges slightly below the annular ligament, supported by the quadrate ligament.

Inferior joint: The convex head of the ulna is accommodated in the concave medial side of the

lower end of the radius. The medial edge of the lower end of the radius is attached to base of styloid process of the ulna by a triangular fibro-cartilage, so that the styloid process forms the centre of a circle round which the radius moves.

The joint has thin and lax anterior and posterior ligaments.

Synovial membrane is separate from that of wrist. It bulges up beneath the pronator quadratus (*membrana sacciformis*) anterior to the interosseous membrane.

The **interosseous membrane** constitutes the **radio-ulnar syndesmosis**. Its fibres are mostly directed downwards and medially, so that a shock passing up the radius would pull on these fibres and so be taken up by the ulna. An independent interosseous band runs upwards from the lower part of the tubercle of the radius to the coronoid process and is called the *oblique cord*; between it and the membrane the posterior interosseous vessels pass to the back of the forearm.

Quadrate Ligament: Lax fibrous bands joining radius and ulna immediately below superior radio-ulnar joint.

Pronation and Supination: These are rolling movements of radius and hand about a fixed ulna. Axis of rotation passes through centres of curvatures of head of radius and head of ulna. Almost always these movements are *accompanied simultaneously* by abduction or adduction of lower end of ulna in order to centre the grip of the hand (e.g. turning a door knob, screwdriver, etc.).

THE WRIST-JOINT

This is only the joint between the forearm and the proximal row of carpal bones; the other joints are intercarpal. The slightly concave distal surface of the radius articulates with the convex proximal surfaces of the scaphoid and lunate bones, and the triangular fibro-cartilage separates the head of the ulna from the triquetral; note that the triquetral

only touches the cartilage when the hand is strongly adducted.

Ligaments: Anterior and posterior ligaments run medially and distally from the radius. Lateral and medial ligaments run from the styloid processes of radius and ulna to carpal bones. All these also form ligaments of the carpal joints.

Movements: These are flexion-extension and abduction-adduction. In working position of almost full pronation of forearm, common movement is of hammering a nail in, *i.e.* extension-abduction and flexion-adduction. Former movement is anti-gravity and is performed by two radial extensor muscles (*longus* and *brevis*), while a single muscle serves each other movement.

CARPAL JOINTS

The important features of these are the interosseous ligaments which limit individual joint cavities. They occur:

(1) Between the bones of the proximal row, shutting off the carpal joints from the wrist-joint.

(2) Connecting the distal row of bones, thus shutting off a large complex mid-carpal joint from the carpo-metacarpal joints. These are not always complete, so that the joints may communicate.

The **pisiform** has an independent joint with the triquetral. Extensions of the tendon of the flexor carpi ulnaris form the pisi-hamate and pisi-metacarpal ligaments, the latter reaching base of fifth metacarpal.

CARPO-METACARPAL JOINTS

The first (that of the thumb) is an independent joint. The other four are subdivided by an interosseous ligament from the capitate to the 3rd metacarpal, so that there is a lateral joint between the trapezoid and capitate and the 2nd and 3rd metacarpals; and a medial joint between the hamate and the 4th and 5th metacarpals. These joints communicate with the three joints between the bases of the

four inner metacarpals. The joints between the metacarpals are limited distally by the interosseous (deep transverse) metacarpal ligaments.

CARPO-METACARPAL JOINT OF THE THUMB

This joint is quite independent of the others structurally and functionally. It has saddle-shaped facets on the trapezium and base of the first metacarpal, and a loose capsule. It allows of flexion, extension, adduction, abduction and circumduction. At rest plane of thumb metacarpal is at *right angle* to remaining metacarpals. In opposition saddle shape of base causes slight rotation of first metacarpal (note change of direction of thumb nail during opposition).

METACARPO-PHALANGEAL JOINTS

These are between the convex head of the metacarpal and the single oval concave facet on the proximal end of the proximal phalanx.

Anteriorly the ligament is tough and forms a **fibro-cartilaginous plate**; posteriorly it is thin, and lax. Thus flexion is free, but extension hardly possible beyond the straight position. The head of the metacarpal is wider in front than behind, and the **collateral ligaments** are attached to the posterior part of the head. The result is that the fingers are locked in flexion, but can be moved from side to side in extension.

INTERPHALANGEAL JOINTS

Each of these is a hinge-joint with well-marked **collateral ligaments**. The head of a phalanx has a double convex knuckle, the base a corresponding double concave facet.

THE JOINTS OF THE PELVIS

THE SACRO-ILIAC JOINT (Figs. 10 and 11)

The sacro-iliac joint transmits the weight of the body through the pelvis to the lower limb. It is a synovial joint, but the articular surfaces (*auricular*

surface of sacrum and of ilium), while coated with hyaline cartilage, are tuberculated and interlock with one another. Behind and above the articular surfaces are extensive rough areas connected by strong *interosseous sacro-iliac ligaments*, which "suspend" the vertebral column between the two innominate bones. Note that the sacrum is wedge-shaped in transverse section—the base of the wedge is antero-inferior—so that the sacrum is not "wedged" into the pelvis, but is "prevented from falling into the pelvis" by the ligaments.

Connecting structures — Sacro-iliac ligaments:

(a) Interosseous mentioned above.

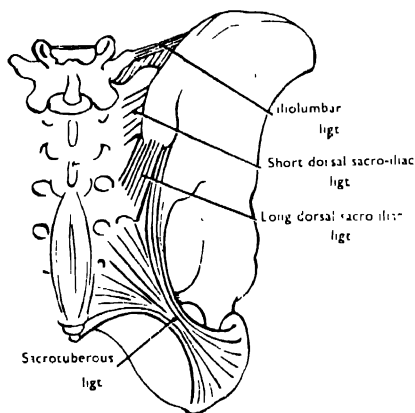


FIG. 10.—THE SACRO-ILIAC JOINT SEEN FROM BEHIND.

Note the relation of the sacro-tuberous ligament to the lowest fibres of the long dorsal sacro-iliac ligament.

(b) **Anterior**—connect anterior margins of articular surfaces.

(c) **Posterior : Short**—connect upper part of sacrum to ilium.

Long (oblique)—connect lower part of sacrum to ilium; continuous with sacro-tuberous ligament

Accessory ligaments: These are not connected directly with the joint, but function in respect to the joint.

(a) **Sacro-tuberous ligament**—from back of sacrum to tuberosity of ischium.

(b) **Sacro-spinous ligament**—anterior to sacro-tuberous; from side of sacrum to spine of ischium.

NOTE.—These two ligaments hold down the posterior part of the sacrum, resisting the tendency of the weight



FIG. 11.—SHOWING THE TENDENCY OF THE WEIGHT OF THE BODY TO TWIST THE SACRUM FORWARDS AND THE FUNCTION OF THE SACRO-SPINOUS AND SACRO-TUBEROUS LIGAMENTS IN RESISTING THIS TENDENCY.

of the vertebral column to push down the front of the sacrum and so to tip up the back.

(c) **Ilio-lumbar ligament**—from the transverse process of the 5th lumbar vertebra to the iliac crest. A strong band, which being directed backwards and upwards as well as laterally, acts as a suspensory ligament for the column.

Important relations: Passing down in front of the joint are the obturator nerve and the lumbo-sacral trunk and first sacral nerve.

Also in front of the joint, separated by fat containing the nerves, are the bifurcations of the common iliac

vessels—the veins being nearer to the joint. Ureters cross pelvic brim in front of each joint.

THE SYMPHYSIS PUBIS

The symphysis pubis is a secondary cartilaginous joint between the apposed surfaces of the pubic bones.

The bony surfaces are coated with hyaline cartilage, and the cartilaginous surfaces are firmly united by an **interpubic disc** of fibro-cartilage. The fibro-cartilage may contain a small non-synovial cavity.

Ligaments are anterior, posterior, superior and inferior or subpubic (arcuate)

The **subpubic ligament** is a thick band, continued above into the interpubic disc and having extensive attachment along the edges of the subpubic arch. It is separated from the perineal membrane (triangular ligament) by the deep dorsal vein of the penis.

THE JOINTS OF THE LOWER LIMB

THE HIP-JOINT (Figs. 12 and 13)

This is a **ball-and-socket** joint with great range of movement. It differs, however, from the shoulder-joint in that great stability is required to bear the superimposed weight. Accordingly, the head of the femur fits snugly into the deep acetabular fossa; the ligaments are strong, and the freedom of movement of the thigh depends on the shaft of the femur being held away from the pelvis by the relatively long neck.

Articulating structures—Acetabulum : Faces largely downwards for weight-bearing. It is a cup-shaped fossa with prominent margins which are interrupted below at the *acetabular notch*. A large area extending from the notch to the centre of the acetabulum is not covered by articular cartilage, but is occupied by the *Haversian pad* of soft fat covered with synovial membrane. Rim of acetabulum is made more prominent by a fibro-cartilaginous *acetabular labrum* (cf. shoulder-joint); this forms a complete ring, bridging over the notch as the *transverse ligament*.

Head of femur : Forms two-thirds of a sphere; shows small pit below and behind centre for attachment of *ligament of head (ligamentum teres)*.

Connecting structures—Capsule : This is strong and is attached outside the acetabular labrum and to the transverse ligament. Distally it covers the whole neck of the femur in front, extending to the intertrochanteric line; but it leaves the lower part of the neck uncovered behind, being attached to the neck $\frac{1}{2}$ inch proximal to the intertrochanteric crest. Small arteries passing up under the edge of the capsule to the neck and head of the femur carry with them fibrous bands, which form reflections of the capsule along the neck known as *retinacula*. The capsule in some cases is perforated medially and in front by the bursa under the psoas.

Ilio-femoral ligament (Y-shaped ligament of Bigelow) : Spreads like an inverted Y down front of joint, from lower part of anterior inferior iliac spine to intertrochanteric line. Consists of very strong lateral and medial bands with thinner intermediate part inseparably blended with capsule. This ligament is very strong. It prevents hyperextension of the hip-joint.

NOTE.—The psoas bursa is *medial* to this ligament.

Ischio-femoral ligament : Fibres from ischium to back of capsule, mostly encircling back of neck transversely and forming *zona orbicularis*.

Pubo-femoral ligament : Fibres on medial aspect of joint from ilio-pubic eminence to medial part of capsule.

Ligament of head of femur (ligamentum teres) : A flattened band which passes inside the acetabulum from the margins of the acetabular notch to the pit on the head of the femur. It carries with it a sheath of synovial membrane and a small artery to head of femur.

The **synovial membrane**, in addition to lining the capsule, also covers the neck up to the articular cartilage of the head, and dips in under the transverse ligament to cover the Haversian pad of fat and to ensheath the ligament of the head.

Nerve supply: Branches from the obturator, sciatic (nerve to quadratus femoris) and femoral (Hilton's Law).

Arterial supply: Branches from the obturator, medial circumflex and gluteal. Head of femur supplied with blood by arteries that pass along neck

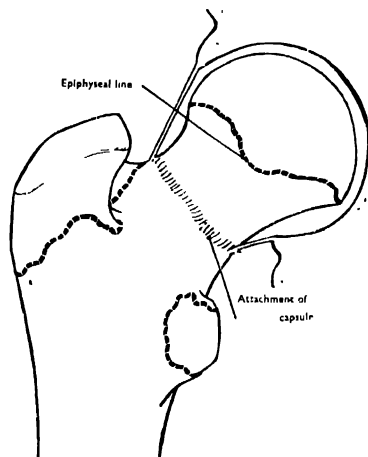


FIG. 12.—DIAGRAM OF LEFT HIP-JOINT OPENED FROM BEHIND.

Note that the capsule extends little more than half-way down the neck. The epiphysis of the head of the femur is entirely intracapsular.

beneath the retinacular fibres of capsule; fracture of neck within the capsule thus likely to cause avascular necrosis of head of femur.

NOTE.—The epiphysis at the junction of the head with the neck of the femur is entirely intracapsular.

Movements: Because of the long neck of the femur, rotation of the head within the acetabulum produces (or is produced by) the various angular movements

of the femur. Accordingly, when we speak of flexion, extension, etc., at the hip, we really mean those movements of the shaft of the femur. Thus, when the femur is flexed or extended, the head rotates around a transverse axis; when the thigh is abducted

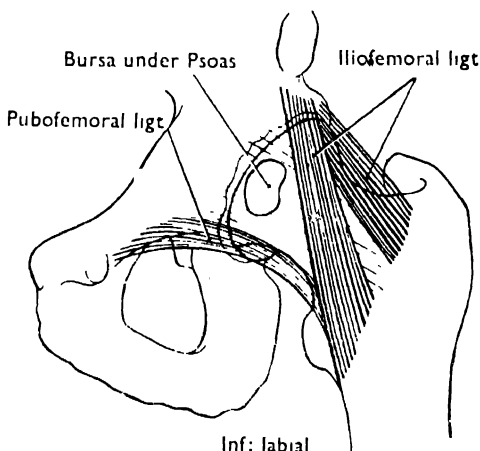


FIG. 13.—LEFT HIP-JOINT FROM THE FRONT.

Note that the capsule extends down the whole of the neck.

or adducted, the head rotates around an antero-posterior axis; when the thigh is rotated the head rotates around a vertical axis. Note that muscles passing in front of the vertical axis must rotate the fully-extended femur *medially* (iliopsoas, pectineus, adductor longus).

THE KNEE-JOINT (Figs. 14 and 15)

This is essentially a hinge-joint, but allows of a little rotation in flexion. The expanded lower extremity of the femur articulates with the expanded

upper end of the tibia, and also with the patella. As it is a weight-bearing joint it requires to be very stable; the expansion of the bony ends helps this, but there is no great adaptation of their shapes to one another; stability depends here on very strong ligaments—intra- and extra-articular, and on muscles.

Articulating structures : The lower end of the femur (Fig. 14) consists of the condyles for the tibia and the patella.

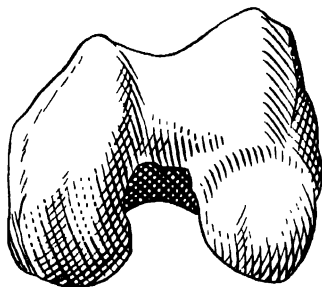


FIG. 14 — LOWER END OF LEFT FEMUR, TO SHOW DIFFERENCES BETWEEN CONDYLES.

The lateral condyle is the more prominent.

The condyles project backwards and are separated by the intercondylar notch; they are separated from the patellar surface by shallow grooves. The medial condyle is lower (with the femur vertical), narrower and longer from before backwards than the lateral, and is also curved from before backwards, whereas the lateral is straight. This is in adaptation to the lateral rotation of the tibia during extension (see p. 36). The patellar surface is convex and prominent laterally and concave medially. The posterior surface of the patella is concave laterally and convex medially. The lateral condyle of the tibia is broad from side to side, and the medial is oval with its

long axis antero-posterior—these corresponding to the femoral condyles. The posterior border of the lateral condyle of the tibia is rounded off for the lateral meniscus (see p. 101).

Connecting structures—Extra-articular : (1) The **capsule** is thin and much strengthened by special ligaments. Posteriorly it is attached to the margins of the femoral condyles and the intercondylar line above, and to the upper margins of the tibial condyles below; at the back of the lateral tibial condyle it is separated from the bone by the tendon of popliteus (see p. 101).

Anteriorly the capsule is perforated where joint communicates with suprapatellar bursa; it attaches to the tibia along the anterior margins of the condyles. Thus the femoral epiphyseal line is within the capsule anteriorly only; the tibial epiphyseal line is entirely extracapsular.

(2) The **medial ligament**: A broad flat triangular band attached above to the medial epicondyle of the femur. Posterior fibres are attached to the medial meniscus (see below); superficial fibres pass downwards and forwards to the medial surface of the shaft and are attached four inches below the condyle.

(3) The **lateral ligament**, round and cord-like, is quite free from the capsule. It is attached above to the lateral epicondyle of the femur; below to the head of the fibula in front of the styloid process and under cover of the biceps tendon; its fibres run downwards and backwards. The **arcuate ligament** is a thin band arching from the styloid process across the popliteus to the capsule and the lateral meniscus.

(4) The **ligamentum patellæ** and the **retinacula** : The **ligamentum patellæ**, continuous through the patella with the quadriceps tendon (p. 89), is thick and strong. It stretches from the apex and lower border of the patella to the tubercle of the tibia. The **retinacula** are expanded lateral parts of the quadriceps tendon going to the tibia and reinforcing the **ligamentum patellæ**.

NOTE.—The **ligamentum patellæ** and the depressed area of the tibia above the tuberosity are

a pad of soft fat and a bursa; the fat adapts itself to fill in the varying open angle between the tibia and the femur.

(5) The **oblique posterior ligament** is an expansion upwards and laterally from the tendon of the semimembranosus to the back of the capsule. It is very strong and is perforated by the middle genicular vessels and nerve.

Intra-articular connecting structures: These are the strong *cruciate ligaments*—anterior and posterior.

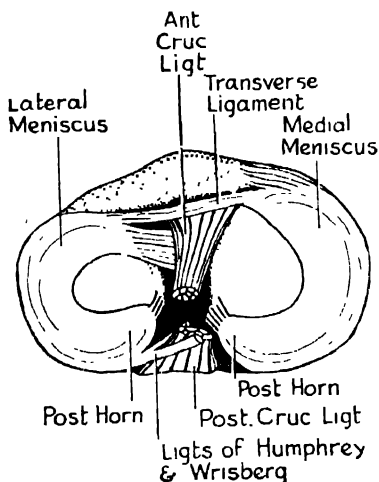


FIG. 15.—THE ATTACHMENTS OF THE SEMILUNAR CARTILAGES.
Plateau of left tibia from above

They connect the femur to the tibia, lie within the fibrous capsule but outside the synovial membrane (which ensheathes them anteriorly and at the sides), and they cross each other X-wise, the anterior lateral to the posterior.

The **anterior cruciate ligament** connects the front of the intercondylar fossa of the tibia to the back of the medial aspect of the lateral condyle. The

THE KNEE-JOINT

posterior cruciate ligament connects the back of the intercondyloid fossa of the tibia to the front of the lateral aspect of the medial condyle.

The Semilunar Cartilages (Menisci): Each meniscus is a C-shaped fibro-cartilaginous structure, wedge-shaped on section, avascular except at its attachments. Base of wedge is attached to joint capsule except where popliteus tendon intervenes in case of lateral meniscus. Thin edge of wedge insinuates between femur and tibia. Free end (cornu) of each meniscus is attached to plateau of tibia by fibrous tissue; anterior parts of menisci connected by transverse ligament. Posterior convexity of lateral meniscus is slung to medial condyle of femur by fibrous slips that embrace the posterior cruciate ligament (ligament of Humphry in front, ligament of Wrisberg behind). These have recently been recognized under the names of anterior and posterior *menisco-femoral ligaments*. *Upper portion of popliteus muscle is inserted into posterior convexity of lateral meniscus.* During rotation of flexed knee, lateral meniscus held by menisco-femoral ligaments and by popliteus in constant position relative to femoral condyle. Medial meniscus, lacking such control mechanism, much more liable to injury.

Synovial membrane: This lines the capsule, but leaves the capsule posteriorly to pass forwards round the cruciate ligaments which lie between it and the back of the capsule. Above the patella it communicates with suprapatellar bursa extending 3 or 4 inches up the shaft of the femur. Below the patella it is pushed into the joint by the pad of fat, and forms a fold or ridge on each side of the pad—the *alar folds*—and in the mid-line a thin double layer of membrane actually gets attached to the cartilage of the femur—the *infrapatellar fold (ligamentum mucosum)*. In the adult the menisci are not covered by synovial membrane.

Bursæ communicating with knee-joint:

- (1) The suprapatellar bursa.
- (2) The popliteus bursa, which often opens into superior tibio-fibular joint.

- (3) Frequently the bursa between the medial head of gastrocnemius and the medial condyle.

Bursæ in neighbourhood not opening into joint :

- (1) Prepatellar, subcutaneous over patella, swollen in housemaid's knee.
- (2) Infrapatellar. (a) Subcutaneous over ligamentum patellæ, swollen in clergyman's knee, and (b) deep to ligamentum patellæ in front of tibia.
- (3) Between insertions of sartorius, gracilis and semitendinosus.
- (4) Beneath semimembranosus's tendon, often communicating with medial gastrocnemius bursa and thence with knee.
- (5) Under lateral head of gastrocnemius.
- (6) Between lateral ligament and biceps tendon.

Nerve supply : From femoral, obturator and sciatic nerves (Hilton's Law).

Blood supply : Genicular branches of popliteal artery, middle genicular direct to cruciate ligaments.

Movements : The knee undergoes flexion and extension, and can be rotated slightly when flexed.

Full extension is accompanied by slight lateral rotation of the tibia (or medial rotation of the femur if the foot is on the ground). The adaptation of the bony surfaces to this has been described (p. 32); the cause of the rotation is the pull of the extensors against the tight and oblique anterior cruciate ligament. The completely extended knee is said to be "locked" because it will maintain the body in the upright position without muscular effort. The weight of the body passes just in front of the centre of the knee, and in front of the medial and lateral ligaments, so that these and the anterior cruciate ligament resist the weight and enable the muscles to relax. Flexion from this position is initiated by the popliteus, which rotates the femur laterally or the tibia medially, and is said to "unlock" the joint.

THE TIBIO-FIBULAR JOINTS

The fibula is very strongly bound to the tibia below, but has a small synovial joint at its upper end

Superior tibio-fibular joint (synovial): A plane oval facet on the postero-lateral angle of the lateral condyle of the tibia (on the epiphysis) faces downwards and laterally to articulate with a similar facet on the head of the fibula. The joint has a capsule with anterior and posterior ligaments.

Nerve supply: From nerve to popliteus and recurrent genicular nerve.

The **interosseous membrane** constitutes the middle *tibio-fibular syndesmosis*. The fibres of the membrane are mostly directed downwards and laterally. It is imperfect above, where the anterior tibial vessels pass forwards, and below, where the perforating peroneal artery pierces it.

The **inferior tibio-fibular joint** (syndesmosis): This consists of a thick interosseous ligament joining rough triangular areas of more than 1 inch in vertical extent on the two bones. There are in addition *anterior and posterior inferior tibio-fibular ligaments*; the posterior extends below the lower edge of the tibia and forms part of the socket receiving the talus.

In addition, there is an extension of the ankle-joint into the extreme lower part of the tibio-fibular joint, the surfaces here being covered with articular cartilage.

Movements: Fibular facet of talus is commonly convex in antero-posterior direction; hence flexion-extension of ankle joint rotates fibula about its long axis, with movement at superior synovial joint.

The strength of the inferior joint is a vital factor in the stability of the lower limb; obviously the weight of the body and the counter-thrust of the talus would separate the two bones were they not very strongly bound together.

THE ANKLE-JOINT (Figs. 16 and 17)*

This is a hinge-joint with good adaptation of surfaces, but its strength nevertheless depends

partly on ligaments and largely upon the tonic action of surrounding muscles.

Articulating structures : The lower ends of the tibia and fibula (strongly bound together; see p. 37) form a deep mortice to receive the body of the talus. Only the tibia articulates with the upper surface of the talus; the malleoli of the tibia and fibula grip the talus at the sides. The facet on the medial side of the talus is comma-shaped, with a large non-

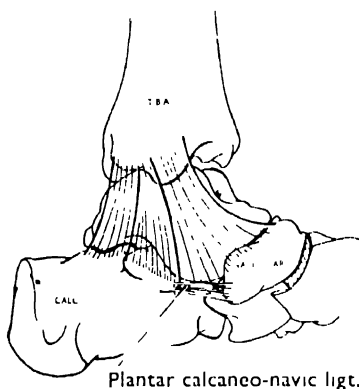


FIG. 10.—LEFT ANKLE-JOINT SEEN FROM THE MEDIAL SIDE TO SHOW THE ATTACHMENTS OF THE DELTOID LIGAMENT.

articular area below it; the lateral facet is triangular (apex down), and covers the whole of the side of the body of the talus. Reciprocally, the lateral malleolus is lower than the medial, and strongly resists eversion at the ankle. The socket and the body of the talus are wider in front than behind, so that the dorsi-flexed ankle is locked, while the plantar-flexed ankle can move slightly from side to side.

NOTE.—The socket is slightly deepened by the posterior inferior tibio-fibular ligament, which has

a special facet along the lateral edge of the body of the talus.

Connecting structures: The capsule is thin and attached round the margins of the articular surfaces. The collateral ligaments are strong.

The **deltoid** is strong and triangular. Deep fibres run from the medial malleolus to the rough surface on the medial aspect of the body of the talus. Superficial fibres spread out from the malleolus to the tuberosity of the navicular, plantar calcaneo-navicular (spring) ligament (p. 41), sustentaculum tali and medial tubercle of the talus.

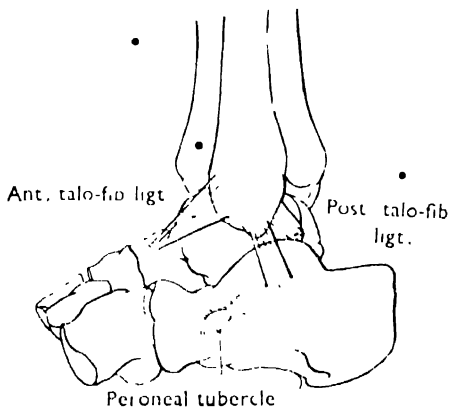


FIG. 17.—LATERAL VIEW OF LIGAMENTS OF ANKLE-JOINT.
Note also the position of the peroneal tubercle and grooves.

The **lateral ligament** consists of three distinct bands:

(a) *Anterior talo-fibular ligament*, between front of malleolus and side of neck of talus.

(b) *Calcaneo-fibular ligament*, between malleolus and a tubercle (above and behind the peroneal tubercle) on the lateral surface of the calcaneum.

(c) *Posterior talo-fibular ligament*, from the deep pit behind articular surface of lateral malleolus,

runs horizontally to lateral tubercle of talus; it impresses a groove on the talus.

The **synovial membrane** has an outlying part at the top of the short cavity between the lower ends of the tibia and fibula (see p. 37).

Arteries and nerves enter the joint from malleolar arteries and from anterior and posterior tibial nerves.

Movements : These are mainly flexion (plantar flexion) and extension (dorsi-flexion). When the toes are pointed downwards there is slight abduction and adduction, owing to the narrow part of the talus being in the wide part of the socket. In standing the ankle is locked; probably the weight of the body causes a slight amount of "give" between the tibia and fibula, so that the talus has, as it were, wedged its way into the socket, thus ensuring great stability.

THE TARSAI JOINTS

There are gliding joints (allowing very little movement) and some special ligaments between all the tarsal bones. Important movements, however, take place between the talus and the rest of the foot as a whole. These occur at what is clinically called the *subtalar joint*, which is a composite of two joints—the *talo-calcaneal* and the *talo-calcaneo-navicular*.

THE TALO-CALCANEAL JOINT

Between the body of the talus and the body of the calcaneum.

Articulating structures : A concave facet on the under surface of the body of the talus articulates with a corresponding convex facet on the body of the calcaneum.

Connecting structures : A capsule surrounds the joint, and the different parts of this are named. The anterior part is really the posterior fibres of the interosseous ligament.

Interosseous talo-calcaneal ligament : Consists of two strong bands lying obliquely in the tarsal canal

(i.e., between posterior facet on calcaneum and sustentaculum tali) and a third more laterally in the sinus tarsi connecting calcaneum to neck of talus (lig. cervicis tali).

Movements: Described below, since this joint and the next function as one.

THE TALO-CALCANEO-NAVICULAR JOINT

Articulating structures: The head of the talus is received into a composite socket made up of parts of the calcaneum and navicular and of certain ligaments.

(1) Anteriorly the head fits into the hollow posterior surface of the navicular.

(2) Inferiorly head of talus rests on a facet on the sustentaculum tali and one on front of calcaneum; these two facets may fuse into one.

(3) In front of the sustentaculum tali the head of the talus rests on the inferior calcaneo-navicular (spring) ligament.

(4) Laterally and inferiorly the socket is completed by the medial (calcaneo-navicular) limb of the bifurcate ligament.

(5) Between the two bones and the two ligaments lies a Haversian fat pad covered with synovial membrane.

NOTE.—The **spring ligament** extends from the front of the sustentaculum tali to the tuberosity of the navicular and the under surface of that bone. It is strong and elastic and an important support of the head of the talus in the medial arch of the foot. The **ligamentum bifurcatum** is a small Y-shaped band extending from the calcaneum behind to the navicular (medial limb) and cuboid (lateral limb) in front.

Movements: These two joints function together. The foot is inverted and everted by approximately ball-and-socket movements in the anterior joint, which result in gliding movements in the posterior joint. These movements are limited by the strong interosseous ligament.

Inversion of the foot is produced by simultaneous contraction of tibialis anterior and tibialis posterior.

Eversion is produced by the peronei (longus, brevis and tertius). The movement begins in the *midtarsal joint* (calcaneo-cuboid and talo-navicular) but is restricted here. Continuing movement goes on in the subtalar joint. Axis of this latter movement passes through centres of curvature of the two subtalar joints; it is oblique from lateral tubercle of calcaneum up and medially through neck of talus. Thus inversion gives also adduction of front of foot, eversion gives abduction. When pure antero-posterior inversion and eversion occur, the unwanted adduction and abduction are cancelled out by rotation of the lower limb at hip or knee.

The other tarsal joints do not require special descriptions, but the following features should be noted:

The **long and short plantar ligaments** run forwards from the under surface of the calcaneum and form ligaments of the calcaneo-cuboid joint.

The **short plantar ligament** is attached to a groove at the anterior end of the under surface of the calcaneum and to the ridge forming the posterior boundary of the groove on the cuboid.

The **long plantar ligament** lies superficial to the short. It extends from the anterior margins of the tubercles of the calcaneum, right along the sole of the foot to the cuboid, covers over the peroneus longus tendon in the groove, and reaches the under surfaces of the lateral cuneiforms and of the bases of the 2nd, 3rd and 4th metatarsals. It is an important support of the lateral arch of the foot.

Interosseous ligaments join the three cuneiforms to one another, the lateral cuneiform to the cuboid, and the navicular to the cuboid.

TARSO-METATARSAL JOINTS

The 1st metatarsal has a large kidney-shaped facet for the front of the 1st cuneiform; the 4th and 5th metatarsals articulate with the cuboid. The first joint has a definite capsule, the others have dorsal and plantar ligaments, and the bases of all the metatarsals are joined by interosseous ligaments.

Note that the line of the joints across the foot is

not transverse, nor is it even. The long base of the 2nd metatarsal dips into a mortice between the long 1st and 3rd cuneiforms, to reach the short middle cuneiform. Note also that the medial side of the base of the 2nd metatarsal is connected to the 1st cuneiform by a strong interosseous ligament.

The **metatarso-phalangeal** and **interphalangeal joints** sufficiently resemble those of the hand not to require further description. Note, however, that the heads of the metatarsals are rather more tightly held together than those of the metacarpals.

ARCHES OF THE FOOT

Longitudinal :

- (a) *Medial*: Consisting of calcaneum, talus, navicular, three cuneiforms and medial three metatarsals.
- (b) *Lateral*. Calcaneum, cuboid, lateral two metatarsals.

Transverse :

Bases of metatarsals. Each foot really half an arch, lateral side on ground, medial side at upper limit of arch.

Factors maintaining the arches :

- (a) **Medial longitudinal.** (i) *Muscular*: Flexor hallucis longus, lies below arch and gives slip to 2nd and 3rd toes; flexor digitorum longus; tibiales anterior and posterior; flexor digitorum brevis; (ii) *Ligamentous*. Plantar aponeurosis, spring ligament, interosseous ligaments.
- (b) **Lateral longitudinal:** (i) *Muscular*: Peroneus longus, flexor digitorum longus to 4th and 5th toes, flexor digitorum brevis; (ii) *Ligamentous*: plantar aponeurosis; long and short plantar ligaments.
- (c) **Transverse:** (i) *Muscular*: peroneus longus; (ii) *Ligamentous*: interosseous; (iii) *Bony*: shape of intermediate and lateral cuneiforms.

CHAPTER TWO

The Muscles

INTRODUCTION

1. The terms Origin and Insertion are retained in subsequent descriptions because they are concise; but it cannot be too strongly urged that the student should appreciate the fact that there is no objective reality in such terms. When a muscle contracts it shortens; which end moves and which remains stationary depend on circumstances, and remain constant in very few muscles.

2. In a multitude of commonly performed movements gravity assists; and a muscle opposing gravity has an opposite action to that commonly described—e.g. in sitting from standing the quadriceps is the *flexor* of the knee in that it resists the sudden flexing action of gravity. This is called the **action of paradox**.

3. The term *raphé* is used to denote the inter-digitation of musculo-tendinous fibres. A raphé can be elongated, concertina-like. A ligament consists of longitudinal fibres which cannot be elongated.

4. A nerve does not perforate a muscle; in apparent examples of such, the nerve really passes in planes of separation between morphologically distinct muscle masses. Such nerves supply the muscles they "perforate."

THE MUSCLES OF THE HEAD AND NECK

THE "MUSCLES OF EXPRESSION"

(Fig. 19)

The 'musculature of the 2nd branchial arch migrates during development to form a thin double sheet which spreads out over the neck (platysma).

face (muscles of expression) and scalp (muscles of scalp and of external ear); *these are all supplied by the facial (7th cranial) nerve.*

The platysma—*Origin*: The fascia over the upper part of the chest and shoulder. Forms a wide sheet covering side of neck—fibres directed upwards and medialwards.

Insertion: Lower border of mandible, and spreads up on to face as risorius (see p. 51).

NOTE.—The platysma lies in the deep part of the superficial fascia of the neck; it covers the external jugular vein and the cutaneous branches of the cervical plexus (p. 261).

THE MUSCLES OF THE FACE

Are arranged around the apertures, eye, nose and mouth. Each aperture possesses a sphincter and a dilator mechanism.

MUSCLES OF THE EYELIDS

Orbicularis oculi is the sphincter muscle and consists of three parts:

(1) **Orbital part** (surrounding orbit).

Origin: Frontal and maxillary bones at medial part of orbit.

Insertion: Skin only, encircles orbit and has no bony insertion laterally.

(2) **Palpebral part** (slightly arched fibres in eyelids).

Origin: Medial palpebral ligament.

Insertion: Lateral palpebral raphe.

NOTE.—Palpebral ligament and raphe are attached to medial and lateral bony margins of orbit, and split to go to edges of eyelids.

(3) **Lacrimal part** (muscle of Horner), attached to lacrimal sac.

Origin: Lacrimal crest, forming posterior edge of lacrimal fossa.

Insertion: Deep aspect of medial palpebral ligament.

Nerve supply of the whole muscle 7th.

Actions: Very different in the two parts.

The *palpebral part* closes the lids gently edge to edge, no diminution in volume of conjunctival sac, so that tears are not extruded, but on the contrary by blinking are pumped via lacrimal sac into the nose. This part is opposed by levator palpebræ superioris (*v. inf.*).

The *orbital part* closes the lids forcibly, with diminution in volume of the conjunctival sac. An eye brimful of tears is caused to spill over down the cheeks. Opponent of this part is occipito-frontalis.

The **levator palpebræ superioris** arises within the orbit and is inserted into the skin, tarsal plate and conjunctiva of the upper lid. It is antagonist to the orbicularis and is supplied by the 3rd nerve. Inferior part of levator is smooth muscle, supplied by sympathetic from superior cervical ganglion via carotid plexus. Upper lid droops if sympathetic pathway is interrupted.

The **muscles of the eyeball** are described with the visual apparatus (p. 318).

Corrugator supercilii : This muscle acts on the skin of the forehead, but is described as a muscle of the eyelids being a detached portion of the orbicularis oculi.

Origin : Frontal bone at medial end of superciliary ridge.

Insertion : Fibres directed upwards and laterally through orbicularis oculi to skin of forehead.

Action : Produces frown of vertical wrinkles above nose ("frown of anger").

MUSCLES OF THE SCALP AND EXTERNAL EAR

Note that these belong to the same group as the muscles of expression, and are supplied by the 7th nerve.

The **scalp** consists of three layers closely bound together:

- (1) Skin.
- (2) Superficial fascia.
- (3) Strong deep fascia (epicranial aponeurosis) with occipitalis muscle attached to it behind and frontalis muscle in front.

These three layers move as a whole on the periosteum of the skull (pericranium), being separated from this by a shallow space (subaponeurotic space).

Occipitalis—*Origin*. Lateral two-thirds of superior nuchal line

Insertion: Posterior part of epicranial aponeurosis.

Action: Pulls scalp backwards, or fixes scalp to allow frontalis to pull on skin of forehead (see below). It is supplied by the posterior auricular nerve.

Frontalis—*Origin*. Anterior part of epicranial aponeurosis.

Insertion: Skin of forehead.

Action: Produces broad wrinkles across forehead (wrinkles of "reflection"). The muscle produces elevation of the eyebrows (as in looking upwards) and is the opponent of the orbital part of orbicularis oculi. *Regarded functionally* the scalp is a prolongation of the face over the skull vertex to the highest nuchal line.

Auricularis muscles: These are three small muscles inserted into the deep (cranial) aspect of the pinna.

The **anterior** and **superior** arise from the temporal fascia and receive nerves from the temporal branches of the facial. The **posterior** arises from the mastoid process and is supplied by the posterior auricular nerve.

MUSCLES OF THE NOSE

(All supplied by 7th nerve—see above)

Compressor naris (the sphincter)—*Origin*: Maxilla at side of lower part of bony anterior nares.

Insertion: Aponeurosis continued across nose to fellow of opposite side.

Action: Compresses upper part of cartilaginous nasal aperture.

Dilator naris—*Origin*: Maxilla below compressor naris.

Insertion: Side of alar cartilage.

Action: Pulls on lateral wing of cartilage to open up nostril.

Procerus : A continuation of median fibres of frontalis down on to nose.

Origin : Fascia over bridge of nose

Insertion : Skin of lower and median part of forehead.

Action : Produces small transverse wrinkles at root of nose by slight elevation of external nose.

MUSCLES OF THE MOUTH

(All supplied by 7th nerve—see above.)

Sphincter of mouth : **Orbicularis oris** (Fig. 18). Has its own proper fibres attached to bone above and below in midline, the *incisive* and *mental* slips. Its bulk is much increased by fibres received from buccinator (p. 49) and the dilator muscles described below. It encircles the lips.

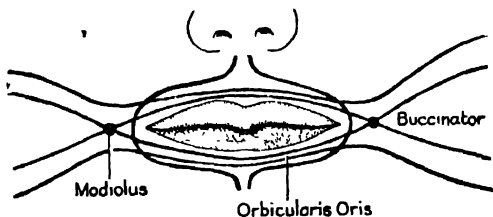


FIG. 18.—THE ARRANGEMENT OF FIBRES IN THE ORBICULARIS ORIS MUSCLE.

Action is to close the mouth into a small circle, as in whistling.

Dilators of mouth : Are arranged radially around the lips; consist of elevators of upper lip and angle of mouth and depressors of lower lip and angle of mouth.

Upper lip : The *levator labii superioris* arises from the infra-orbital margin, and is inserted into the upper lip.

The *levator labii superioris alaeque nasi*—*Origin :* Upper part of frontal process of maxilla.

THE MUSCLES OF THE NECK

SUPERFICIAL MUSCLES OF THE SIDE OF THE NECK

The **platysma** is described with the "second arch" muscles (p. 45).

The **trapezius** is described with the muscles of the upper limb (p. 66).

The **sterno-mastoid** (Fig. 22, p. 54)—*Origin*: By two heads:

Sternal head: From front of manubrium sterni by a rounded tendon.

Clavicular head: From upper border and front of medial one-third of clavicle by muscular fibres.

Insertion: Outer surface of mastoid process and lateral two-thirds of superior nuchal line. Medial fibres from clavicle pass up deep to accessory nerve and to sternal belly of the muscle to the mastoid process, forming the "cleido-mastoid" part of the muscle.

Nerve supply: Spinal part of spinal accessory nerve. Proprioceptive from C. 2 and 3.

Action: The two muscles together flex the neck and extend the skull (i.e. they protract the face, keeping it vertical). One alone pulls head down towards same shoulder, turning face to opposite side with chin elevated.

NOTE.—Torticollis is due partly to contraction of the sterno-mastoid, and the position of the head and face illustrates the action of one muscle.

Important relations of sterno-mastoid: It separates the anterior from the posterior triangle of the neck (Fig. 22). The carotid sheath lies under cover of its lower part, and along its anterior border above. The upper part of sternomastoid conceals the cervical plexus lying on scalenus medius.

The nerves of the cervical and brachial plexus appear at its posterior border. The spinal part of the accessory nerve runs backwards and downwards through its deep fibres.

The **cervical fascia** (Fig. 23): This consists of a "cylinder" around the neck (investing layer) and a complex system of septa between the neck muscles and other

structures. The **investing layer** is attached behind to the ligamentum nuchæ, and is continuous round the neck; it joins its fellow-layer in the mid-line in front. This layer splits to ensheathe the trapezius and sterno-mastoid muscles. It is attached below to the clavicle and to the top of the sternum; the sternal attachment is split to anterior and posterior layers, which enclose the "space of Burns" containing the anterior jugular veins. The clavicular part is likewise split, its deep lamina binding the inferior belly of

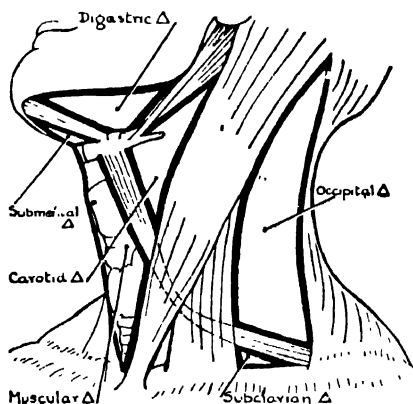


FIG. 22.—THE TRIANGLES OF THE NECK AND THE MUSCLES BOUNDING THEM

omo-hyoid to the clavicle. External jugular vein pierces both laminae below omohyoid, just above midpoint of clavicle.

Above, it is attached to the lower border of the mandible and to the zygomatic arch and occipital nuchal lines, and encloses the parotid gland and covers the masseter (p. 51).

A transverse septum passing between the prevertebral muscles (p. 59) and the pharynx and œsophagus constitutes the **prevertebral fascia**; this fascia extends laterally and covers cervical and

brachial plexuses and muscles in floor of posterior triangle. Attached above to basi-occiput, it extends down over longus cervicis into superior mediastinum

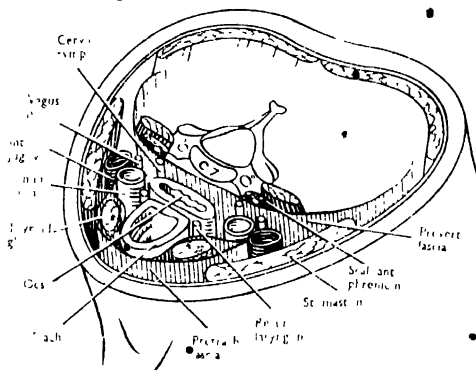


FIG. 23.—DIAGRAM OF THE COMPARTMENTS INTO WHICH THE NECK IS DIVIDED BY THE CERVICAL FASCIA.

attached to body of fourth thoracic vertebra. It forms a base upon which pharynx, oesophagus and carotid sheath slide in swallowing and neck movements

The **carotid sheath** is areolar tissue, strong over carotid arteries, weak over jugular vein (to allow for expansion of latter). Is attached above near tympanic plate of temporal bone.

The **pretracheal fascia** is suspended from hyoid bone and thyroid cartilage across the larynx. It invests the thyroid gland and passes down into the thorax behind the innominate veins to the pericardium. Laterally it blends with front of carotid sheaths.

THE SUPRAHYOID MUSCLES

The **digastric** consists of two bellies connected by an intermediate tendon.

Origin—Anterior belly: Digastric fossa on either side of back of symphysis of mandible.

• **Posterior belly** : Digastric groove on base of skull under cover of mastoid process.

Insertion : Each belly is inserted into intermediate tendon, which is not attached to bone, but held in a loop of fascia which holds it down to the side of the body and adjacent part of great cornu of hyoid bone.

Nerve supply : Anterior belly, mylo-hyoid branch of mandibular of 5th; posterior belly, facial nerve near exit from stylo-mastoid foramen. (First and second arch muscles respectively.)

Action : Depression of mandible or elevation of hyoid bone.

NOTE.—The digastric bounds the digastric triangle (Fig. 22, p. 54), containing the submandibular gland. The muscle is a landmark for the 7th nerve (above it) and the 12th nerve (below it), while the occipital artery runs under cover of its posterior belly.

The stylo-hyoid : A small slip lying along the upper border of the posterior belly of the digastric, derived like it from the 2nd arch, and supplied by the facial nerve.

Origin : Outer surface of root of styloid process (pointed tendon).

Insertion : Fibres split over digastric tendon to reach body and lesser cornu of hyoid bone.

Nerve supply. Facial.

Action : Elevation of hyoid bone in swallowing.

The mylo-hyoid : A flat thin sheet of muscle forming the floor of the mouth.

Origin : Whole length of mylo-hyoid ridge of mandible.

Insertion : Fibres are directed medially to meet fellow of opposite side in a median raphé which stretches from the mandible to the hyoid bone; the most posterior fibres are inserted into the body of the hyoid bone.

Nerve supply : Mylo-hyoid branch of mandibular on its inferior surface (cf. anterior belly of digastric).

Action : Elevation of hyoid and midline raphé, raises floor of mouth. Presses up on tongue in swallowing.

Genio-hyoid : Is really upper extension of pre-tracheal infrahyoid muscles, in series with rectus abdominis and supplied segmentally by spinal nerves.

Origin : Inferior genial tubercle on back of symphysis menti.

Insertion : Anterior surface of body of hyoid bone above mylo-hyoid.

Nerve supply : Hypoglossal (fibres from C.¹ 1).

The muscles of the tongue are described in the section on the tongue (p. 321).

The muscles of the pharynx are described in the section on the pharynx (p. 328).

The muscles of the palate are described in the section on the palate (p. 324).

The muscles of the larynx are described in the section on the larynx (p. 358).

THE INFRAHYOID MUSCLES (Fig. 24)

Sterno-hyoid : Narrow strap-like muscles *converging upwards* in front of neck.

Origin : Back of sterno-clavicular joint and adjacent parts of clavicle and manubrium

Insertion : Lower border of body of hyoid bone close to midline.

Nerve supply : Ansa hypoglossi (C. 1, 2, 3).

Action : Depression of hyoid bone.

Sterno-thyroid : Wider muscles, under cover of sterno-hyoids, and *diverging upwards*.

Origin : Back of first costal cartilage, and adjacent part of manubrium sterni.

Insertion : Oblique line on outer aspect of thyroid cartilage.

Nerve supply : Ansa hypoglossi (C. 1, 2, 3).

Action : Depression of larynx.

NOTE.—Diamond-shaped space in mid-line between these muscles of the two sides contains trachea, cricoid, thyroid cartilage, isthmus of thyroid gland and inferior thyroid veins.

Omo-hyoid : Two bellies united by an intermediate tendon; the muscle extends obliquely across the neck from hyoid bone to scapula.

Origin : Suprascapular ligament and adjacent part of upper border of scapula.

Insertion : Lower border of body of hyoid bone lateral to sterno-hyoid.

NOTE.—Intermediate tendon lies over carotid sheath and under sterno-mastoid, and is held down to clavicle by a fascial investment (Fig. 26, p. 27).

Nerve supply Superior belly from descendens hypoglossi (C. 1)

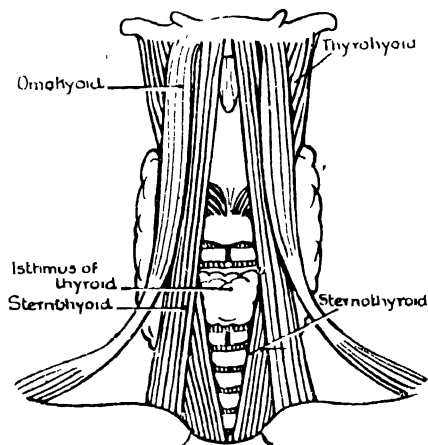


FIG. 24.—THE INFRAHYOID MUSCLES AND THE THYROID GLAND.

Note the "diamond-shaped" space of operations on the respiratory tract.

Inferior belly from ansa hypoglossi (C. 1, 2, 3)

Action: Pulls hyoid bone down and back.

NOTE.—Anterior belly separates carotid triangle above from muscular triangle below. Posterior belly separates occipital triangle above from sub-clavian triangle below

Thyro-hyoid—*Origin*: Oblique line of ala of thyroid cartilage.

Insertion: Lower border of great cornu of hyoid bone.

Nerve supply: Hypoglossal (fibres from C. 1).

THE PREVERTEBRAL MUSCLES

These form a group lying on the front of the cervical and upper thoracic vertebræ.

The longus cervicis consists of three portions:

Vertical portion: Slips from fronts of bodies of upper four thoracic vertebræ to fronts of bodies of 2nd, 3rd and 4th cervical vertebræ.

Lower oblique portion: Slips from upper thoracic vertebræ directed upwards and laterally to transverse processes (anterior tubercles) of 5th and 6th cervical vertebræ.

Upper oblique portion: Slips from transverse processes (anterior tubercles) of 3rd, 4th and 5th cervical vertebræ directed upwards and medially and converging on to anterior tubercle of atlas.

Nerve supply: Anterior branches of C. 2, 3, 4.

Action: Flexion and lateral flexion of neck.

The longus capitis—*Origin:* Like scalenus anterior from anterior tubercles of transverse processes of 3rd, 4th, 5th and 6th cervical vertebræ.

Insertion: Base of skull on inferior surface of basi-occipital bone.

Nerve supply: Anterior branches of C. 1, 2, 3.

Action: Flexion of head and upper part of neck.

The rectus capitis anterior—*Origin:* Front of lateral mass of atlas.

Insertion: Basi-occipital bone close to condyle and beneath longus capitis.

Nerve supply: Branches from first loop of cervical plexus (C. 1, 2).

Action: Flexion of head at occipito-atlantal joint.

The rectus capitis lateralis—*Origin:* Upper surface of transverse process of atlas.

Insertion: Under surface of jugular process of occipital bone.

Nerve supply: Anterior division of C. 1.

Action: Lateral flexion of head to same side.

These short muscles adjust and stabilize skull on spine.

THE LATERAL VERTEBRAL MUSCLES (SCALENES)

These three muscles connect the cervical column to the 1st and 2nd ribs.

The scalenus anterior—*Origin*: Anterior tubercles of transverse processes of 3rd, 4th, 5th and 6th cervical vertebræ.

Insertion: Scalene tubercle on inner border of 1st rib, by narrow tendon.

Nerve supply: Branches from cervical plexus (C. 4, 5).

Action: Flexion and lateral flexion of neck, or elevation of 1st rib.

The scalenus medius—*Origin*: Posterior tubercles and costo-transverse bars of transverse processes of 2nd to 6th cervical vertebræ.

Insertion: Into large area of upper surface of 1st rib behind subclavian groove.

Nerve supply: Branches from cervical nerves (anterior primary rami C. 3-7).

Action: Lateral flexor of neck or elevator of 1st rib.

NOTE.—Brachial plexus and subclavian artery emerge between these two muscles.

The scalenus posterior is really a special part of the scalenus medius passing across the 1st rib to reach the 2nd rib.

Origin: Posterior tubercles of transverse processes of 5th, 6th and 7th cervical vertebræ.

Insertion: Posterior part of outer surface of 2nd rib.

Nerve supply: C. 5, 6, 7.

Action: Lateral flexor of neck or elevator of 2nd rib.

THE MUSCLES OF THE DORSAL ASPECT OF THE TRUNK AND NECK

The trapezius, latissimus dorsi, levator scapulæ and rhomboids are really muscles of the upper limb (see pp. 66, 68).

Under these are the **splenius** and the **posterior serrati**; and under these in turn come the great group of **dorsal muscles of the vertebral column**, with

the special suboccipital group just below the skull.

The splenius (capitis et cervicis)—*Origin* (common to both parts): (1) Lower half of ligamentum nuchæ.

(2) Spines of 7th cervical and first 5 or 6 thoracic vertebræ.

Insertion: Muscle forms flat wide band directed upwards and laterally to mastoid process and occipital bone deep to sterno-mastoid (p. 53) and into posterior tubercles of 2nd and 3rd cervical transverse processes.

Nerve supply: 4th to 8th cervical *posterior primary divisions*.

Serratus posterior superior—*Origin*: Spines of 7th cervical and upper three thoracic vertebræ deep to splenius.

Insertion: Thin sheet of fibres directed downwards and laterally to outer surfaces of 2nd to 5th ribs beyond angles.

Nerve supply: 3rd and 4th intercostal nerves (i.e. *anterior primary divisions* of thoracic nerves).

Action: Elevator of upper ribs (feeble).

Serratus posterior inferior—*Origin*: Spines of last two thoracic and upper two lumbar vertebræ.

Insertion: Fibres directed laterally and upwards to outer surfaces of lower four ribs beyond angles.

Nerve supply: 9th, 10th and 11th intercostal nerves (i.e., *anterior primary divisions*).

Action: Depressor or fixer of lower ribs.

THE DEEP MUSCLES OF THE VERTEBRAL COLUMN

These extensor muscles of the vertebral column include not only those inserted into the vertebræ, but certain longitudinal muscles inserted into ribs near the vertebral column, and some partially inserted into the back of the head. All lie deep to thoraco-lumbar fascia, and are known collectively as **erector spinæ**.

All these muscles may conveniently be divided into three groups:

(a) Short muscles between adjacent vertebræ; these are rotators (**rotatores**), lateral flexors (**intertrans-**

verse muscles) and extensors (*interspinales*). They are the deepest of the series.

(b) Muscles running obliquely from transverse processes below to spines or laminae above, missing several vertebræ between origin and insertion; these are: the **multifidus**, which misses one or two vertebræ and is placed immediately superficial to the *rotatores*, and the **semispinalis**, which misses four to six vertebræ and lies superficial to the *multifidus*. These two muscles combine extension with lateral flexion and rotation. Part of the *semispinalis* is inserted into the back of the skull.

(c) Superficially placed longitudinal muscles with a long interval between origin and insertion, and the principal action of which is extension of the spine, while certain of them also laterally flex the spine. These muscles are known collectively as the **sacrospinalis** because they have an extensive common origin below. From the common origin three columns arise—the medial or **spinalis** (spines to spines), intermediate or **longissimus** (common origin to transverse processes and ribs), and the lateral or **ilio-costalis** (common origin to ribs near their angles). Special slips of these muscles are continued up into the neck.

Nerve supply: All these muscles of the spine are supplied segmentally by the *posterior primary divisions* of the spinal nerves of their particular region.

Lumbar fascia: Three lamellæ, fused laterally along a line from 12th rib to iliac crest. Posterior lamella attached to tips of spinous processes of lumbar and sacral vertebræ, intermediate lamella to tips of lumbar transverse processes, anterior lamella to front of transverse process (Fig. 34). Posterior lamella continues upwards over thorax (thoraco-lumbar fascia) attached to thoracic spinous processes and angles of ribs, fades out over lower part of neck. Extensor muscles of spine lie in posterior compartment, *quadratus lumborum* in anterior compartment.

Rotatores: Eleven separate muscles on each side found only in the *thoracic region*.

Origin: Back of transverse process of a vertebra.

Insertion: Base of spine of vertebra immediately above.

Intertransversales: Two on each side (anterior and posterior); best marked in cervical region.

Origin: Upper border of transverse process.

Insertion: Lower border of transverse process immediately above.

Multifidus—*Origin*: A series of bundles from:

- (1) Back of sacrum and sacro-iliac ligaments.
- (2) Mamillary processes of lumbar vertebrae.
- (3) Backs of transverse processes of thoracic vertebrae
- (4) Articular processes of cervical vertebrae.

Insertion: Fibres pass up and in to reach the sides of the spines of vertebrae above, missing two to four vertebrae before reaching insertion.

Semispinalis—*Origin*: A series of long bundles from the backs of the tips of the thoracic transverse processes (1st to 10th) and the articular processes of the cervical vertebrae (3rd to 7th).

Insertion: *Semispinalis thoracis*, Spines of C. 6-7, T. 1-4.

Semispinalis cervicis, Spines of C. 2-5.

Semispinalis capitis, Occipital bone between superior and inferior nuchal lines, close to mid-line and immediately under trapezius.

Sacro-spinalis (erector spinæ)—*Origin*: Superficial to origin of multifidus (*vid. sup.*):

- (1) Sacral spines and lateral mass (transverse processes).
- (2) Lumbar and lower thoracic spines.
- (3) Posterior part of crest of ilium.

Insertion: Three columns as described, and each column consists of three parts.

(1) **Outer column**:

- (a) **Ilio-costalis**: From common origin to lower six ribs near angles.
- (b) **Costalis**: From lower six ribs to upper six ribs.
- (c) **Costo-cervicalis**: From upper six ribs to

- transverse processes of lower three or four cervical vertebræ.
- (2) **Intermediate column** (*longissimus*):
- (a) **Longissimus thoracis**: (1) Transverse processes of all the thoracic and lumbar vertebræ; (2) by lateral slips to lower ten ribs just lateral to tubercles.
 - (b) **Longissimus cervicis**: Fresh slips arise from upper thoracic transverse processes and go to cervical articular processes (2nd to 6th).
 - (c) **Longissimus capitis**: Slips arising as longissimus cervicis go up to back of mastoid process under cover of sternomastoid and splenius capitis (p. 61).
- (3) **Medial column** (*spinalis*) Origin is part of common origin, but from spines only.
- **Spinalis thoracis**: Spines of upper four to eight thoracic vertebræ.
 - Spinalis cervicis**: From upper few thoracic spines to upper few cervical spines (2, 3, 4).

THE SUBOCCIPITAL MUSCLES

These are a group of small muscles in the same plane as the deep vertebral muscles, and connecting the upper two cervical vertebræ to one another or to the head. All supplied by suboccipital nerve (P.P.D.). (Fig. 25).

Obliquus capitis inferior—*Origin*: Spine of axis.

Insertion: Back of transverse process of atlas.

Nerve supply: Suboccipital nerve (C. 1)—*posterior* primary division.

Action: By rotating atlas, and therefore skull, turns face to same side.

Obliquus capitis superior—*Origin*: Upper surface of transverse process of atlas.

Insertion: Lateral part of area on occipital bone between superior and inferior nuchal lines.

Nerve supply: Suboccipital nerve (P.P.D. of C. 1).

Action: Extends head and pulls it to same side, acting over occipito-atlantal joint.

Rectus capitis posterior major—*Origin* : Spine of axis.

Insertion : Lateral part of area on occipital bone below the inferior nuchal line (overlapped by superior oblique).

Nerve supply : Suboccipital nerve (P.P.D. of C. 1).

Action : Extensor of head

Rectus capitis posterior minor—*Origin* : Posterior tubercle on arch of atlas.

Insertion : Medial part of area on occipital bone below inferior nuchal line (medial to and overlapped by rectus major).

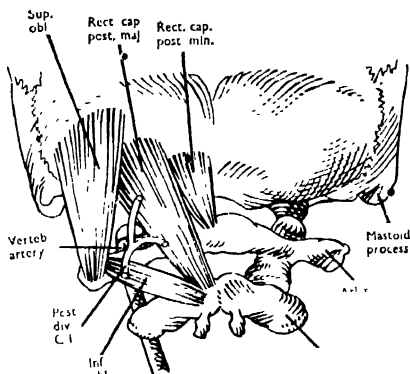


FIG. 25.— THE SUBOCCIPITAL REGION.

Nerve supply : Suboccipital nerve (P.P.D. of C. 1).

Action : Extensor of head

NOTE.—The two recti posteriores, the lateral recti and the anterior recti have a special function in fixing the skull firmly on the atlas during rotation.

Suboccipital triangle (Fig. 25): The three sides are: rectus capitis posterior major, superior and inferior oblique muscles. Floor contains posterior arch of atlas and vertebral artery piercing posterior atlanto-occipital membrane. Great occipital nerve (P.P.D. of C. 2) crosses roof. Posterior primary

ramus of C. 7 runs from under vertebral artery back into extensor muscles on roof. Between the two suboccipital triangles lie rectus capitis posterior minor muscles.

1. THE MUSCLES OF THE UPPER LIMB

Included in this section are muscles which might appear to belong to the trunk—*e.g.* trapezius, levator scapulae and rhomboids. The clavicle and scapula, however (pectoral girdle), belong to the limb, so that muscles inserted into these bones act on the limb and are therefore grouped as muscles of the limb.

The muscles of the upper limb fall into the following groups:

(1) Muscles connecting limb to trunk:

(a) Posterior group, connecting limb to vertebral column.

(b) Anterior group, connecting limb to thoracic wall.

(2) Muscles of the shoulder

(3) Muscles of the arm.

(4) Muscles of the forearm.

(5) Muscles of the hand

1 (a). POSTERIOR MUSCLES, CONNECTING LIMB TO VERTEBRAL COLUMN

Trapezius: An extensive triangular sheet covering the back of the neck and the upper part of the back.

Origin: Medial one-third of superior nuchal line of occipital bone; external occipital protuberance; ligamentum nuchae (see p. 7); spines and supraspinous ligaments of all the thoracic vertebrae.

Insertion: Lateral one-third of posterior border of clavicle; medial border of acromion and upper border of spine of scapula. Lower fibres converge to "deltoid tubercle."

Nerve supply: Spinal part of accessory nerve (p. 257) and branches from C. 3, 4 (proprioceptive)—all entering its deep aspect.

Action (Fig. 26): Elevates shoulder by upper fibres (shrugging); rotates scapula with serratus anterior

(p. 70) in raising arm; two trapezii with levator scapulæ and rhomboids brace shoulders back.

In addition, trapezius is an important postural muscle; its tonus keeps the shoulder in its normal elevated position; when the accessory nerve is injured the shoulder droops.

NOTE.—Anterior border of trapezius forms posterior boundary of posterior triangle of neck.

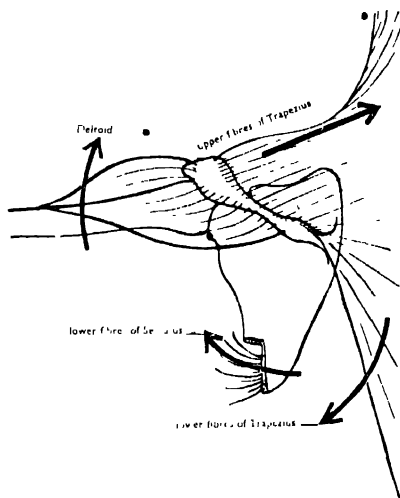


FIG. 26.—ACTIONS OF THE MUSCLES WHICH RAISE THE ARM.

The deltoid raises the humerus to a right-angle with the scapula; the trapezius and the lower fibres of the serratus anterior meanwhile rotate the scapula as shown, to raise the arm above the shoulder.

Latissimus dorsi: A thin sheet covering the lower part of the back.

Origin: Spines and supraspinous ligaments of lower six thoracic vertebræ under cover of lower part of trapezius; by lumbar fascia from spines of all lumbar vertebræ and outer lip of posterior part of crest of ilium; muscular slips join its deep

surface from lower four ribs and from angle of scapula. The iliac fibres form the posterior boundary of the lumbar triangle (of Petit).

Insertion : Narrows to a flat tendon which is inserted into floor of bicipital groove (between teres major medially and pectoralis major laterally).

NOTE —The muscle twists on itself as it ascends to humerus, and curves round the teres major, forming the rounded lower border of the posterior wall of the axilla.

Nerve supply : Nerve to latissimus dorsi (middle subscapular) from posterior cord of brachial plexus (C. 6, 7, 8), entering its axillary surface near the anterior border.

Action : Adduction, medial rotation and extension of arm (as in breast stroke in swimming). Will elevate trunk to arm already fixed in raised position (e.g., horizontal bar, climbing).

Levator scapulæ—*Origin* : Posterior tubercles of transverse processes of upper four cervical vertebræ.

Insertion : Vertebral border of scapula from superior angle down to root of spine.

Nerve supply . C. 3, 4, assisted by nerve to rhomboids (C. 5).

Action : Assists upper fibres of trapezius in elevating and maintaining level of scapula.

Rhomboids : These form a small thick sheet of muscle extending downwards from the vertebral spines to the vertebral border of the scapula. They act together in bracing back the shoulders, or in elevating and maintaining the level of the scapula. They lie under cover of the trapezius.

Rhomboid major arises from the spines of the 2nd to the 5th thoracic vertebræ and is inserted to the vertebral border of the scapula from the root of the spine to the inferior angle.

Rhomboid minor extends from the lower part of the ligamentum nuchæ and the spines of C. 7 and T. 1 to the vertebral border of the scapula opposite the root of the spine.

Nerve supply : The nerve to the rhomboids (C. 5), which, having passed under and supplied the levator

scapulæ, passes also deep to these two muscles and supplies them on their deep surface. The nerve lies with descending scapular vessels on serratus posterior superior.

1 (b). --MUSCLES CONNECTING LIMB TO THORACIC WALL

Pectoralis major—*Origin*: (1) The medial half of the anterior surface of the clavicle.

(2) The whole length of the front of the sternum.

(3) The fronts of the upper six costal cartilages.

(4) Rectus sheath (i.e. external oblique aponeurosis).

Insertion: The whole length of the lateral lip of the bicipital groove. Tendon of insertion is folded to become bilaminar. Clavicular and manubrial heads inserted into anterior lamina; sternal fibres twist under these to reach posterior lamina, lowest fibres of origin inserted as high as capsule of shoulder joint.

Nerve supply: Lateral (C. 6, 7) and medial (C. 8, T. 1) pectoral nerves.

Action: Adducts, medially rotates and flexes arm. With arm fixed in abduction raises ribs (accessory muscle of inspiration).

Pectoralis minor: Lies under cover of pectoralis major.

Origin: 3rd, 4th and 5th ribs near junction with cartilages. Commonly also from 2nd rib.

Insertion: Medial border of coracoid process.

Action: Pulls scapula forwards and depresses shoulder.

Nerve supply: Medial pectoral (C. 8, T. 1).

Clavipectoral fascia: Fascia attached to clavicle around subclavius extending down to upper border of pectoralis minor, from anterior intercostal membrane to coracoid process. Pierced by acromio-thoracic artery, lateral pectoral nerve, cephalic vein and lymphatic

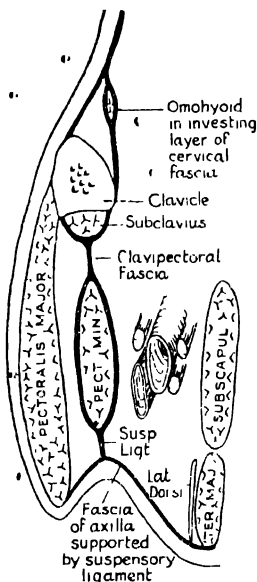


FIG. 27.—DIAGRAM OF VERTICAL SECTION THROUGH AXILLA

which accompany it. Traced around pectoralis minor becomes suspensory ligament of axilla—hence hollow in armpit if clavicle be raised (Fig. 27).

The fascia of the pectoral muscles contains important lymphatic plexuses which drain the mamma.

Subclavius muscle: This arises by a tendon from the upper surface of the 1st rib near its cartilage, and spreads laterally and upwards to its insertion into the subclavian groove on the under surface of the clavicle. It is supplied by the nerve to the subclavius from C. 5 and 6.

Action: Depressor of clavicle, and stabilizes the clavicle for movements of arm.

NOTE.—The axillary vessels and the brachial plexus lying on the 1st rib are separated from the clavicle by the subclavius muscle.

The nerve to the subclavius is given off from the upper trunk of the plexus, runs down in front of the plexus and of the subclavian vein, and often gives off the important accessory phrenic nerve (p. 265).

Serratus anterior (magnus)—Origin: By digitations from outer surfaces of the upper eight ribs.

Insertion: Ventral aspect of whole length of vertebral border of scapula.

The first digitation arises from the 1st and 2nd ribs, and is inserted into the upper angle of the scapula.

The next three arise from the 2nd, 3rd and 4th ribs, and spread out as thin sheets inserted along the vertebral border.

The lowest four digitations, from ribs 5 to 8, converge on to the inferior angle of the scapula.

Action : Draws scapula forwards, making a stable basis for action of arm in front of the body; lower fibres rotate scapula so that glenoid fossa faces upwards to support arm when raised above shoulder (see Fig. 26, p. 67).

Nerve supply : The long thoracic nerve (of Bell) (C. 5, 6, 7), which runs vertically down the outer surface of the muscle (which is the medial wall of the axilla) deep to its fascia. Nerve lies just behind midaxillary line.

2 — MUSCLES OF THE SHOULDER

The **deltoid** is a massive muscle covering the shoulder-joint and giving to the shoulder its characteristic outline. Acromial fibres multipennate for greater power.

Origin : (1) The lateral one-third of the anterior border of the clavicle.

(2) The outer border of the acromion

(3) The lower edge of the spine of the scapula

Insertion : By a tendon into the outer side of the humerus nearly half-way down the bone, raising a well-marked eminence.

Nerve supply : Circumflex nerve (C. 5, 6), which winds round neck of humerus under cover of the muscle.

Action (Fig. 26, p. 67) : Raises (abducts) arm to horizontal position. Anterior fibres flex and posterior extend arm at shoulder-joint.

Between anterior border of deltoid and upper border of pectoralis major is delto-pectoral groove in which run the cephalic vein and the humeral branch of the coraco-acromial artery. The groove opens out above into the important delto-pectoral (infra-clavicular) triangle, in which is exposed part of the clavipectoral fascia, and in which are one or two lymphatic glands.

The short muscles surrounding the shoulder have individual actions, but act especially together as fixators of the joint in any position into which the longer muscles have moved it.

Supraspinatus—*Origin* : Supraspinous fossa. A bursa separates muscle from neck of scapula.

Insertion : (1) Upper facet on great tuberosity of humerus.

(2) Tendon blends with lateral part of upper part of capsule of shoulder-joint.

Nerve supply : Suprascapular (C. 5, 6) from upper trunk of brachial plexus.

Action : Abductor, but especially fixator, as stated above.

Infraspinatus—*Origin* : Infraspinous fossa. A bursa separates muscle from neck of scapula.

Insertion : (1) Middle facet on great tuberosity of humerus.

(2) Capsule of shoulder-joint—like supraspinatus.

Nerve supply : Suprascapular nerve.

Action : Lateral rotator and fixator.

Teres minor—*Origin* : Upper part of dorsal aspect of axillary border of scapula.

Insertion : Lowest facet on great tuberosity of humerus, and adjoining part of shaft.

Nerve supply : Circumflex nerve (C. 5, 6).

Action : Lateral rotator and fixator.

Teres major—*Origin* : Back of inferior angle and axillary border of scapula below teres minor.

Insertion : Front of humerus—medial lip of bicipital groove. Lies edge to edge with subscapularis.

Nerve supply : Lower subscapular (C. 6, 7).

Action : Medial rotator and adductor of arm at shoulder-joint.

Subscapularis : This muscle covers the front of the shoulder-joint, and forms the greater part of the posterior wall of the axilla, which is completed below by teres major and latissimus dorsi.

Origin : The whole of the subscapular fossa, except the neck of the scapula, where the muscle is separated from bone by a bursa which communicates with shoulder joint. Multipennate fibres arise from fibrous

septa in the muscle, which septa are attached to ridges in the subscapular fossa.

Insertion : Lesser tuberosity of humerus and shaft below this.

Nerve supply : Upper and lower subscapular nerves from posterior cord of plexus (C. 5, 6, 7).

Action : Medial rotator, and also fixator as described above.

Muscular walls of axillary space—*Anterior* : Pectoral muscles, clavipectoral fascia, and suspensory ligament of axilla.

Medial : Serratus anterior.

Posterior : Subscapularis, teres major, latissimus dorsi.

Lateral : Humerus and coraco-brachialis.

The **triangular** and **quadrilateral spaces** are exits from the axilla through the posterior wall; both spaces lie between the subscapularis above and the teres major below; they are separated from one another by the long head of the triceps. Circumflex nerve and posterior circumflex vessels traverse quadrilateral space.

3.—MUSCLES OF THE ARM

Coraco-brachialis—*Origin* : Tip of the coracoid process medial to biceps and by muscular fibres from the medial side of the tendon of short head of biceps.

Insertion : Medial aspect of humerus about half-way down, just above nutrient foramen; muscular fibres frequently extend down in the medial intermuscular septum towards the medial epicondyle.

Nerve supply : Pierced by musculocutaneous nerve, which supplies it (C. 7).

Action : Adductor of humerus.

NOTE.—The coraco-brachialis forms a ridge in the arm; the brachial artery lies behind it, and passes forwards across its insertion.

Biceps : This muscle extends from the scapula to the radius, thus crossing and acting on two joints—the shoulder and the elbow.

Origin : By two heads, short and long :

Short head: From the tip of the coracoid process lateral to coraco-brachialis.

Long head: From the supraglenoid tubercle of the scapula within the fibrous capsule of the shoulder-joint (see p. 19).

The two heads join together about the middle of the arm.

Insertion: (1) Principally by a strong tendon into the back of the tuberosity of the radius. Tendon rotates so that anterior surface at elbow looks laterally at its insertion.

(2) By a fascial band (*bicipital aponeurosis*) from the medial side of the tendon into the deep fascia of the front of the forearm, and so to subcutaneous border of ulna.

Nerve supply: Musculo-cutaneous (C. 5, 6) as it passes under the muscle.

Action: Supinator of forearm; then flexes elbow and shoulder. Long head enhances stability of shoulder-joint.

NOTES.—(1) Demonstrate action of biceps by comparing muscle in flexion and pronation with condition in flexion and supination.

(2) Brachial artery (and median nerve) lie in a visible groove along medial border of the muscle.

(3) Median basilic vein and medial cutaneous nerve of forearm cross bicipital aponeurosis; brachial artery and median nerve lie under cover of it. In each case nerve is medial to vessel.

Brachialis: Lies deeply under cover of lower half of biceps.

Origin: Front of lower half of shaft of humerus, and medial intermuscular septum. Fibres converge downwards to a strong tendon.

Insertion: Coronoid process and tuberosity of ulna.

Nerve supply: Musculo-cutaneous (C. 5, 6).

Action: Flexor of elbow.

The **triceps** constitutes the whole of the muscular mass of the back of the arm, arising from the back of the humerus, and by an additional head from the scapula, and being inserted by a conjoined tendon into the olecranon process of the ulna.

• **Origin—Long head :** From the infraplenoid tubercle of the scapula outside the shoulder-joint (*cf.* biceps, p. 74).

• **Lateral head :** From a ridge on back of humerus above radial sulcus (musculo-spiral groove), extending almost as high as *teres minor*.

• **Medial head :** From the whole width of the posterior surface of the humerus below the spiral groove extending as high as the *teres major*, and from medial and lateral intermuscular septa.

The long and lateral heads join to form a massive tendon; this lies superficial to the medial head, and the fibres of the medial head are inserted into its deep aspect.

• **Insertion :** The tendon is attached to the lower part of the superior surface of the olecranon process. A few fibres of medial head from the lowest part of the origin pass into the capsule of the elbow, constituting the **subanconeus**.

• **Nerve supply :** Radial (musculo-spiral) (C. 7, 8).

NOTE.—Medial head receives two branches: the **ulnar collateral nerve**, given off in the axilla, enters it low down; the second branch is given off in the spiral groove and runs down in the medial head to the anconeus. The long head is supplied in the axilla, and the lateral head in the spiral groove.

Action : Extension of the elbow. Long head supports shoulder-joint in abduction.

NOTE.—The long head forms the boundary between the quadrilateral space laterally and the triangular space medially (see p. 73).

4.—THE MUSCLES OF THE FOREARM

Deep fascia of the forearm : This encircles the muscles of the forearm, sending septa in between them, and is attached posteriorly to the subcutaneous border of the ulna.

The **flexor retinaculum** (a ligament in its own right) stretches transversely across the front of the wrist from the scaphoid and trapezium laterally to the pisiform and hamate medially.

The **extensor retinaculum** (a thickening of deep fascia) stretches very obliquely downwards and medially from the distal part of the radius to the pisiform and triquetral, hence unaffected by pronation and supination.

" SUPERFICIAL MUSCLES OF THE FRONT THE FOREARM

These are flexors or pronators. They arise by a **common flexor origin** from the front of medial epicondyle of the humerus and from the fascia over them and the septa between them, certain of them, as stated below, have additional origins.

Pronator teres—*Origin*: Common flexor origin and extends up supracondylar ridge. This muscle has an additional deep origin from the medial aspect of the coronoid process of the ulna.

Insertion: Middle of lateral aspect of radius, i.e. region of greatest convexity for best mechanical advantage.

Nerve supply: Median (C. 6).

Action: Flexion and pronation of forearm.

NOTE.—Nerve to pronator teres is given off in cubital fossa (p. 79) (i.e. in arm). Median nerve passes between two heads of the muscle, and ulnar artery deep to both heads.

Flexor carpi radialis—*Origin*: Common flexor origin as above.

Insertion: Front of base of 2nd metacarpal with slip to 3rd (compare radial extensors, p. 80).

NOTE.—Tendon runs in special sheath in flexor retinaculum and in groove on trapezium.

Nerve supply: Median (C. 6, 7.)

Action: Abductor and flexor of wrist; pure flexor with flexor carpi ulnaris. Fixator of wrist in movements of fingers.

Palmaris longus (may be absent)—*Origin*: Common flexor origin.

Insertion: Into proximal end of palmar aponeurosis (palmar fascia) (see p. 84). Tendon is adherent to flexor retinaculum.

Nerve supply : Median (C. 6, 7).

Action : Tensor of palmar fascia and flexor of wrist.

Flexor carpi ulnaris—*Origin* : (1) Common flexor origin.

(2) Medial margin of olecranon process of ulna.

(3) From aponeurosis attached to upper two-thirds of subcutaneous border of ulna.

Insertion : (1) Pisiform bone.

(2) By extensions to hook of hamate (pisi-hamate ligament), base of 5th metacarpal (pisi-metacarpal ligament) and front of flexor retinaculum.

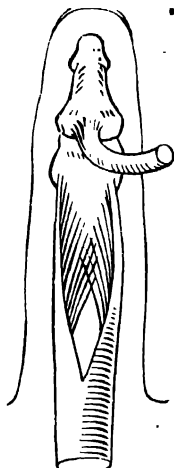


FIG. 28.—THE CHIASMA IN THE TENDON OF THE SUPERFICIAL (SUBLIMIS) TENDON. THE PROFUNDUS TENDON IS DISPLACED.

NOTE.—The true insertion is into the metacarpal bone (*cf.* flexor carpi radialis), the others being “interruptions” of the tendon.

Nerve supply : Ulnar (C. 7, 8, see p. 268).

Action : Ulnar flexion of wrist and fixation (*cf.* flexor carpi radialis).

Flexor digitorum superficialis (sublimis) : Lies in a

plane intermediate between the above muscles and the deep muscles.

Origin: (1) Common flexor origin,

(2) Medial ligament of elbow and highest point of medial margin of coronoid process ("sublime" tubercle).

(3) Oblique line on anterior surface of shaft of radius. Fibrous arch between bones.

Insertion: By four tendons which, after splitting to allow tendons of flexor profundus digitorum to pass through them, join together again, and again split to go to the sides of the middle phalanx of each finger (not thumb). (Fig. 28.)

Nerve supply: Median (C. 7, 8).

Action: Flexor of 2nd phalanx, and secondarily of the other joints which its tendons cross -- up to the elbow.

DEEP MUSCLES OF THE FRONT OF THE FOREARM

Flexor profundus digitorum: Large muscle which gives bulk to medial part of forearm.

Origin: Front and medial surface of shaft of ulna and olecranon above pronator quadratus; and adjacent interosseous membrane

Insertion: By four tendons into terminal phalanges of the fingers; these tendons perforate those of the superficial flexor. (Fig. 28.)

Nerve supply: Anterior interosseous (median) to index and middle fingers, ulnar to ring and little fingers (C. 7, 8); cf. lumbricals.

Action: Flexor of terminal phalanx, and secondarily of other joints of fingers and of wrist

Tendons and sheaths of flexors of fingers—NOTES.—

(1) Common synovial sheath under flexor retinaculum for flexor superficialis (sublimis) and profundus (Fig. 30, p. 82). Flexor superficialis tendons in pairs, middle and ring fingers anterior to index and little finger tendons. Profundus tendons side by side but only index tendon separated at this level (Fig. 30).

(2) Extension of this into palm, and along little

finger tendon to tip of that finger, but not along other fingers.

(3) Synovial sheaths along whole length of index, middle and ring fingers, not continued into palm.

(4) Fibrous tunnels formed along all the fingers, each containing the two tendons and the synovial sheath.

(5) *Vincula vasculosa*—small synovial folds (like mesenteries) connecting tendons to walls of fibrous sheath or to ligaments of interphalangeal joints; they carry supplementary blood supply from digital arteries to the tendons.

(6) On the front of the proximal phalanx the tendon of flexor superficialis (*sublimis*) splits and joins again to form a spiral ring around the tendon of the profundus. It then splits again, as described, to the sides of the 2nd phalanx.

Flexor longus pollicis—*Origin*: Front of shaft of radius—above pronator quadratus and below anterior oblique line.

Insertion: Front of base of terminal phalanx of thumb

Nerve supply: Anterior interosseous of median (C. 7, 8).

Action: Flexion of thumb and secondarily of other joints which it crosses.

NOTE.—Tendon runs in separate synovial sheath under flexor retinaculum, and this sheath is prolonged up to end of thumb. Communicates at wrist level in 50 per cent. of cases with common synovial sheath of digital flexors.

Pronator quadratus: A quadrilateral transverse muscle at lower end of forearm

Origin: Ridge on front of lower quarter of shaft of ulna.

Insertion: Distal quarter of front and medial side of shaft of radius.

Nerve supply: Anterior interosseous of median (C. 7, 8).

Action: By pulling lower end of radius round ulna it pronates the forearm and hand.

NOTE.—The **cubital fossa** is bounded by the pro-

nator teres medially and the brachio-radialis laterally; its floor is formed by the brachialis and the supinator.

SUPERFICIAL MUSCLES OF THE BACK OF THE FOREARM

These are extensors and supinators, *except the brachio-radialis*. The common extensor origin is on the *anterior* part of the lateral epicondyle of the humerus; thus in supination of extended elbow, muscles arising from it curve backwards on to forearm, producing characteristic hollow in which lies head of radius. In working position of almost full pronation extensor muscles pass *straight* into forearm.

Brachio-radialis—*Origin*: Upper two-thirds of lateral supracondylar ridge of humerus.

Insertion: Into radius; outer side of root of styloid process

Nerve supply: Radial (musculo-spiral) (C 5, 6) in the arm.

Action: *Flexion* of elbow in position midway between supination and pronation.

Extensor carpi radialis longus—*Origin*: Lower one-third of lateral supracondylar ridge.

Insertion: Back of base of 2nd metacarpal.

Nerve supply: Radial (musculo spiral) (C. 6, 7) in arm.

Action: Extension of wrist and fixation (synergic) of wrist when long flexors are acting on fingers.

The others of this group arise from the common origin, and certain of them have additional origins.

Extensor carpi radialis brevis—*Origin*: Common extensor origin.

Insertion: Styloid process of base of 3rd metacarpal

Nerve supply: Posterior interosseous (C. 6, 7) in arm.

Action: Extension and fixation (synergic) of wrist

Extensor (communis) digitorum—*Origin*: Common extensor origin.

Insertion: By four flat tendons which spread out on the back of the hand and go one to each finger. Joined in variable manner by oblique intertendinous connexions. The flat tendon on the back of each

finger is the **dorsal or extensor expansion**; it receives the tendons of the lumbricals (p. 86) and interossei

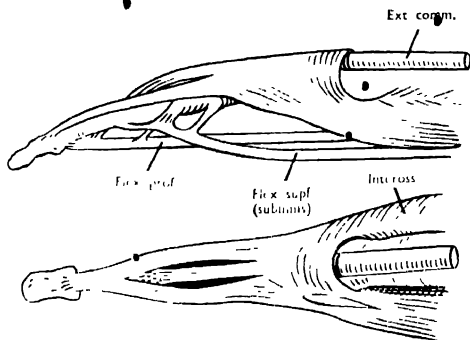


FIG. 29.—THE DORSAL EXTENSOR EXPANSION.

(p. 86), and then its central part goes to the back of the base of the 2nd phalanx, and its margins as two slips to the back of the base of the terminal phalanx (Fig. 29).

NOTE.—The tendons on the back of the hand are *incorporated in the deep fascia*, so that they form with it a complete covering of the back of the hand.

Nerve supply: Posterior interosseous (C. 7, 8).

Action: Extension of digits and secondarily of wrist.

Extensor digiti minimi—**Origin:** Common extensor origin.

Insertion: By two tendons into the extensor expansion of the little finger.

Nerve supply: Posterior interosseous (C. 7, 8).

Action: Extension of little finger.

Extensor carpi ulnaris—**Origin:** (1) Common extensor origin.

(2) By aponeurosis attached to subcutaneous border of ulna (compare flexor carpi ulnaris, p. 77).

Insertion: Dorsal aspect of base of 5th metacarpal.

Nerve supply: Posterior interosseous (C. 6, 7).

Action: Extension and adduction of hand; fixator of wrist when fingers are in action.

Anconeus—*Origin*: Back of lateral epicondyle—tendon.

Insertion: Triangular area on lateral aspect of proximal end of ulna.

Nerve supply: Nerve to medial head of triceps, which runs down to anconeus in substance of triceps.

Action: Helps to stabilize ulna, which it slightly abducts and rotates (pronation, see p. 23).

NOTE.—The anconeus forms a thin triangular sheet covering the head of the radius.

DEEP MUSCLES OF THE BACK OF THE FOREARM

These are the **supinator**, and a series of **long extensors of the thumb and index finger**.

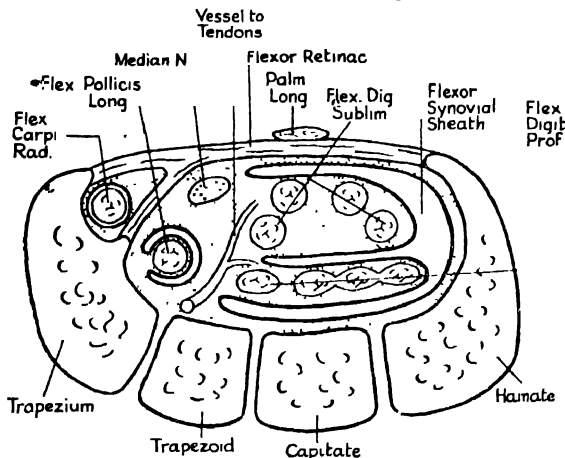


FIG. 30.—THE TENDONS AT THE FLEXOR RETINACULUM TO SHOW THE SYNOVIAL SHEATHS.

The supinator—*Origin*: (1) Deepest (transverse) fibres from supinator crest and area just below radial notch of ulna.

(2) More superficial (oblique) fibres from back of lateral epicondyle, lateral ligament of elbow and anular ligament.

- Insertion :** Neck and shaft of the radius above the oblique lines, the fibres surrounding the bone.

Nerve supply : Pierced by posterior interosseous nerve, which supplies it (C. 6).

Action : Rotates the pronated radius into supination.

Abductor pollicis longus (extensor ossis metacarpi pollicis)—**Origin :** Proximal impression on back of ulna; back of radius below posterior oblique line; adjacent part of interosseous membrane.

Insertion : Lateral aspect of base of metacarpal of thumb.

Nerve supply : Posterior interosseous (C. 7, 8).

Action : Abduction and extension of metacarpal of thumb. Flexor of wrist.

Extensor pollicis brevis—**Origin :** Back of radius, below abductor longus pollicis; and adjacent part of interosseous membrane.

Insertion : Back of base of 1st phalanx of thumb.

Nerve supply : Posterior interosseous (C. 7, 8).

Action : Extension of 1st phalanx, and secondarily abduction of wrist.

Extensor pollicis longus—**Origin :** Back of ulna, below abductor longus pollicis, and adjacent part of interosseous membrane. Long tendon changes direction around dorsal (Lister's) tubercle of radius.

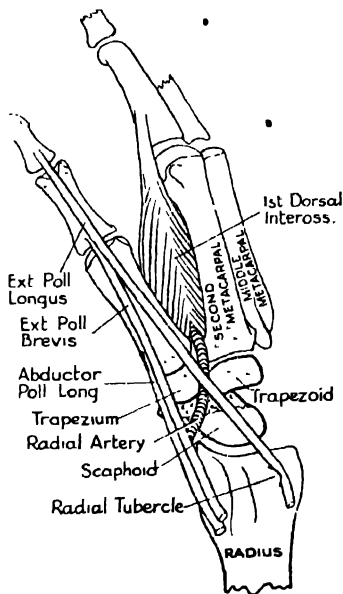


FIG. 31.—CONTENTS OF THE RIGHT "SNUFF-BOX."

tion around dorsal (Lister's)

More distally forms with previous two tendons the "snuff-box" in which are palpable base of thumb metacarpal, trapezium, scaphoid, radial styloid and radial artery (Fig. 31).

Insertion: Back of base of terminal phalanx of thumb.

Nerve supply: Posterior interosseous (C. 7, 8).

Action: Extends thumb, and secondarily wrist.

Extensor indicis—*Origin*: Back of ulna below extensor longus pollicis, and interosseous membrane.

Insertion: Joins dorsal expansion on index finger.

Nerve supply: Posterior interosseous (C. 7, 8).

NOTE.—**Compartments under extensor retinaculum.** These number six: (1) Lateral aspect of radius—abductor longus and extensor brevis pollicis.

(2) Dorsal aspect of radius (from lateral to medial side):

(a) Extensor carpi radialis longus et brevis.

(b) Extensor longus pollicis.

(c) Extensor communis digitorum and extensor indicis

(d) (between radius and ulna) Extensor digiti minimi.

(3) Dorsal aspect of ulna—extensor carpi ulnaris

5.—THE MUSCLES OF THE HAND

The **palmar aponeurosis** is the deep fascia of the palm of the hand. Over the thenar and hypothenar eminences it is thin, but in the hollow of the palm it is thick. This central part is a continuation of palmaris longus. It is attached proximally to the flexor retinaculum, distally it splits into slips to the four digits, which blend with the fibrous flexor sheaths of the fingers. From its lateral aspect a septum passes deeply into the palm to the front of the middle metacarpal, separating off a *thenar* space of the hand from a *mid-palmar* space. The long tendons of the index finger commonly lie in the thenar space.

The **muscles of the hand** are divisible into three groups:

- (1) The muscles of the thumb, forming the *thenar eminence*.
- (2) The muscles of the little finger, forming the *hypothelar eminence*.
- (3) The palmar muscles—namely, the *interossei* and *lumbricals*.

The thumb and little finger each have three superficial muscles, while the thumb has an extra deep muscle. The superficial groups of the thumb and little finger closely resemble one another, and are described together. In addition to the bony origins given below, they arise from the palmar aspect of the flexor retinaculum.

SUPERFICIAL MUSCLES OF THE THUMB AND OF THE LITTLE FINGER

		<i>Thumb</i> (<i>Pollicis</i>).	<i>Little Finger</i> (<i>Minimi Digiti</i>)
Origins	Abductor brevis Flexor brevis	Scaphoid and trapezium Trapezium	Pisiform and hook of hamate. Hook of hamate.
Insertions	Opponens	Trapezium	Hook of hamate.
	Abductor	Lateral side of 1st phalanx	Medial side of 1st phalanx.
	Flexor brevis	Lateral side of 1st phalanx	Medial side of 1st phalanx
	Opponens	Lateral side of whole length of metacarpal	Medial side of 5th metacarpal.
Nerve supplies	--	All by median T.I	All by ulnar. • T.I

NOTE.—The so-called deep head of the flexor brevis pollicis is really the 1st palmar interosseous (see below).

Palmaris brevis: A few transverse fibres in the superficial fascia of the hypothelar eminence; supplied by the ulnar nerve.

DEEP MUSCLE OF THE THUMB
(not represented in little finger)

Adductor pollicis—*Origin*: **Oblique head**: The front of the bases of the 2nd and 3rd metacarpals, and the adjacent part of the carpus (capitate and trapezoid).

Transverse head: The distal two-thirds of the front of the 3rd metacarpal.

Insertion: The two heads join to be inserted into the medial aspect of the base of the 1st phalanx of the thumb.

Nerve supply: The ulnar nerve.

Action: Adduction of the thumb—that is, movement toward the index finger *in the plane of the palm*.

NOTE.—**Sesamoid bones** are developed in the conjoined tendons of the muscles inserted into the medial and lateral sides of the 1st phalanx of the thumb.

The lumbricals: Four slender muscles associated with the tendons of the flexor profundus digitorum.

Origin: 1st and 2nd, from the radial sides of 1st and 2nd tendons.

3rd and 4th, from the adjacent sides of 2nd and 3rd and 3rd and 4th tendons.

Insertion: Each lumbrical tendon passes distally on the palmar aspect of the distal transverse metacarpal ligament and round the radial side of the appropriate finger to be inserted into the dorsal expansion (p. 81) on the middle phalanx (Fig. 29).

Nerve supply: 1st and 2nd (unicapital muscles), by digital branches of median.

3rd and 4th (bicipital muscles), by deep branches of ulnar.

Actions: Flexion of metacarpo-phalangeal joint and extension of interphalangeal joints—*i.e.* flexion of straight finger.

The interossei: These are four dorsal and four palmar, but a part of each dorsal interosseus is in series with the palmar interossei and can be seen in the dissection of the palm. *All eight are supplied by the ulnar nerve.*

Dorsal interossei—*Origins*: From the adjacent sides of two metacarpals.

Insertions : 1st, into radial side of base of proximal phalanx of index finger and into dorsal expansion.

2nd, into radial side of base of proximal phalanx of middle finger and dorsal expansion.

3rd, into ulnar side of base of proximal phalanx of middle finger and dorsal expansion.

4th, into ulnar side of base of proximal phalanx of ring finger and dorsal expansion.

Actions : (1) Abduction of extended fingers from mid-line of middle finger.

(2) Flexion of metacarpo-phalangeal joint and extension of interphalangeal joints (*cf.* lumbricals).

Palmar interossei—*Origins* : 1st, from ulnar side of base of 1st metacarpal.

2nd, from ulnar side of shaft of 2nd metacarpal.

3rd, from radial side of shaft of 4th metacarpal.

4th, from radial side of shaft of 5th metacarpal.

Insertions : 1st and 2nd, into ulnar side of proximal phalanx of thumb and index finger respectively.

3rd and 4th, into radial side of proximal phalanx of ring and little fingers.

Actions : (1) Adduction of fingers to mid-line (*i.e.* to middle finger).

(2) Flexion of metacarpo-phalangeal joints and extension of interphalangeal joints (like dorsal interossei and lumbricals).

NOTE.—Layers of palm :

(1) Palmar fascia.

(2) Superficial arterial arch and median nerve.

(3) Superficial and deep flexor tendons and lumbricals.

(4) Adductor pollicis. Deep arterial arch and ulnar nerve.

(5) Interossei.

THE MUSCLES OF THE LOWER EXTREMITY

THE MUSCLES OF THE ILIAC REGION

The **psoas major** is a massive fusiform muscle extending from the lumbar region of the vertebral column along the pelvic brim and under the inguinal ligament to the thigh.

Origin : (1) The discs *above* the five lumbar vertebræ and adjacent borders of vertebræ (*i.e.*, from lower border of T. 12 to upper border of L. 5).

(2) Muscle fibres arise from fibrous arches stretching across the lumbar vessels and sympathetic rami, as these lie in the hollows of the vertebral bodies.

(3) The medial half of the fronts of all the lumbar transverse processes.

Insertion : By a stout tendon into the tip of the lesser trochanter of the femur.

Nerve supply : From L. 2 and 3.

Action : A flexor and *medial* rotator of extended thigh. Also a muscle of posture; in the standing position it is to be regarded as acting in co-operation with "antagonists"—*e.g.* gluteus maximus—in maintaining the trunk balanced on the lower limbs.

NOTE.—Important relations of psoas: (1) Stout fascial *psoas sheath* enclosing muscle and extending down to inguinal ligament.

(2) Lumbar nerves form lumbar plexus in substance of the muscle

(3) Forms important part of posterior abdominal wall, such structures as ureter, testicular vessels, inferior vena cava lying on it.

(4) In thigh the tendon lies on the front of the hip-joint (with a bursa intervening), and lies behind the femoral artery.

Psoas minor (when present) arises from lower border T. 12, and goes to pectineal eminence.

Iliacus—Origin : The greater part of the iliac fossa, extending on to the sacrum. A large bursa lies beneath it in lower part of iliac fossa.

Insertion : The lateral aspect of tendon of psoas and femur just below.

Nerve supply : A branch from the femoral nerve (L. 2, 3).

Action : As that of psoas.

The iliacus has a fascial sheath like that of the psoas.

THE MUSCLES OF THE THIGH

The deep fascia (fascia lata) of the thigh: This surrounds the muscles and sends septa in, between the principal groups; it is very strong, especially on the lateral aspect of the thigh. It is attached above to the iliac crest, inguinal ligament, ischio-pubic ramus and sacrum. It is pierced obliquely by the **saphenous opening** $1\frac{1}{2}$ inches below the pubic tubercle; from this opening a deeper layer passes in to become continuous with the fascia over the pectineus, and the medial intermuscular septum; between these two layers is the femoral sheath. Saphenous opening covered by *cribriform fascia*, which transmits long saphenous vein and lymphatics.

Below, the fascia is attached to the tibial condyles and to the sides of the patella, blending with the patellar retinacula (p. 33). On the lateral side, a part is thickened to form the **iliotibial band**, which receives the insertions of three-quarters of the gluteus maximus and of the tensor fasciæ latæ (pp. 93, 94). It is inserted into a round facet on front of lateral condyle of tibia.

1. — THE ANTERIOR FEMORAL MUSCLES

These are the massive **quadriceps extensor** with the small **articularis genu** and the **sartorius**. All are supplied by the femoral nerve. The quadriceps is the great extensor of the knee, consisting of three muscles arising from the front and sides of the femur, one from the os innominatum, and all inserted through the patella into the front of the tibia.

Vastus lateralis—*Origin*: By strong aponeurosis from upper half of lateral lip of linea aspera, extending up to side and front of base of great trochanter.

Insertion: Muscular fibres extend downwards and medially to join common tendon of quadriceps, and lower tendinous fibres (retinacula) are inserted into side of patella and lateral part of ligamentum patellæ.

Vastus intermedius: This lies under cover of the other three.

Origin : Upper two-thirds of front and *lateral* aspect of shaft of femur, not from medial aspect

Insertion : Deep aspect of common tendon of quadriceps.

Vastus medialis—**Origin :** Medial lip of linea aspera and extends along spiral line towards great trochanter, and down to medial supracondylar ridge; also by muscular fibres passing forwards from tendon of ischial part of adductor magnus (p. 92).

Insertion : Into common tendon of quadriceps; but lower muscular fibres extend horizontally for-

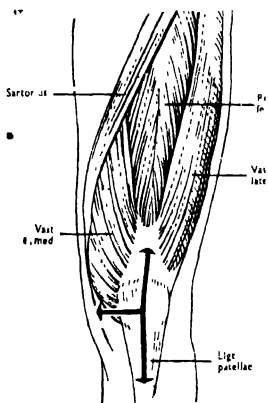


FIG. 32.—INSERTION OF VASTUS MEDIALIS INTO MEDIAL BORDER OF PATELLA, PREVENTING DISLOCATION LATEROALLY WHEN QUADRICEPS CONTRACTS.

wards to medial side of patella, preventing its lateral dislocation (Fig. 32).

NOTE.—The vastus medialis forms the lateral wall of the subsartorial canal.

Rectus femoris : Fusiform bipennate muscle on a plane superficial to the vasti.

Origin : By two heads: straight head from anterior inferior iliac spine; reflected head from upper margin of acetabulum blending with capsule of hip-joint.

Insertion : By massive tendon into upper border of patella; this tendon receives aponeurotic fibres

of the vasti, the whole forming the common tendon of the quadriceps.

The ultimate insertion of these four muscles is into the tubercle of the tibia. The patella is a sesamoid bone in the tendon of the quadriceps, which tendon is continued below the patella as the ligamentum patellæ and the retinacula of the knee.

The **articularis genu** consists of a few muscle-fibres from the front of the femur to the suprapatellar bursa of the knee (p. 35). It pulls up the synovial pouch during extension (compare subanconeus, p. 75).

Action of quadriceps: All components extend knee, rectus femoris also flexes hip. Pull of quadriceps on patella is in line of femur (oblique) while ligamentum patellæ is vertical; horizontal fibres of vastus medialis indispensable in preventing lateral dislocation of patella (Fig. 32).

The **sartorius**—*Origin*: Anterior superior iliac spine and bone below it

Insertion: Upper part of medial surface of tibia in front of semitendinosus and gracilis.

Nerve supply: Superficial division of femoral. (L. 2, 3).

Action: Flexion, abduction and lateral rotation of thigh, and flexion of knee.

NOTE.—The sartorius is thin and ribbon-like, crossing the thigh obliquely superficial to the quadriceps. It forms the lateral boundary of the femoral triangle and the anterior wall of the adductor (sub-sartorial) canal.

2.—THE MEDIAL FEMORAL MUSCLES

These occupy the adductor compartment. *They are supplied by the obturator nerve with the exception of the pectineus and a portion of the adductor magnus.*

Obturator externus—*Origin*: Outer surface of obturator membrane, and adjacent ramus of pubis and ischium.

Insertion: Trochanteric fossa on medial surface of base of great trochanter.

Nerve supply: Posterior division of obturator nerve which leaves pelvis by piercing the muscle (see p. 275).

NOTE.—Tendon of obturator externus winds round distal part of back of neck of femur in contact with the bone.

Adductor magnus—*Origin*: Outer surface of inferior ramus of pubis, of ramus of ischium and of tuberosity of ischium

Insertion: Pubic fibres run nearly horizontally outwards to upward extension of linea aspera (gluteal ridge)

Fibres from ramus of ischium run obliquely to linea aspera and upper part of medial supracondylar ridge.

Fibres from tuberosity form long vertical muscle with tendinous insertion into adductor tubercle (ischial head).

Nerve supply: Posterior division of obturator (L. 2, 3), but ischial head is supplied by sciatic (L. 4, 5).

Action: Adduction and extension of hip-joint.

NOTE.—Ischial head is really a hamstring muscle (cf. *sémimembranosus*, etc., p. 96). Femoral artery passes backwards through "opening in adductor magnus" between the adductor and ischial parts. Perforating arteries (p. 172) pass back through insertion of adductor magnus.

Adductor brevis: Lies immediately in front of magnus.

Origin: Outer surface of pubic ramus above adductor magnus.

Insertion: Upper part of linea aspera and extension of this to lesser trochanter.

Nerve supply: Anterior division of obturator nerve.

Action: Adduction of hip-joint.

NOTE.—This muscle separates the two divisions of obturator nerve.

Adductor longus: Longer, thinner and more oblique than brevis and lies anterior to it.

Origin: Front of body of pubis by stout tendon.

Insertion: Whole length of linea aspera.

Nerve supply: Anterior division of obturator.

Action : Adduction and *medial* rotation of thigh.

NOTE.—This muscle separates femoral and profunda femoris vessels. Medial border forms one side of femoral triangle.

Pectineus : Above and in same plane as adductor longus.

Origin : Pectineal line of pubis and triangular area in front of this.

Insertion : Line from linea aspera to lesser trochanter medial to insertion of adductor brevis.

Action : Adductor and *medial* rotator of thigh.

Nerve supply : Usually anterior division of femoral (L. 2, 3); may be accessory obturator (L. 3)

NOTE.—Pectineus and adductor longus form floor of femoral triangle. Adductor magnus and longus form floor of subsartorial canal

Gracilis : A thin ribbon-like muscle running vertically down medial side of thigh.

Origin : Inferior margin of body and inferior ramus of pubis.

Insertion : Upper part of medial surface of shaft of tibia, behind sartorius and above semitendinosus.

Nerve supply : Anterior division of obturator.

Action : Adduction of thigh and flexion of knee

3.—THE MUSCLES OF THE GLUTEAL REGION

These are the three **glutei**; the **tensor fasciæ latæ** in association with these; and the **lateral rotators**, a series of short muscles closely surrounding the hip-joint

The **glutei** form the mass of the buttock.

Gluteus maximus—**Origin :** (1) Small area on ilium above and behind posterior gluteal line.

(2) Lateral mass of sacrum (costal element) below auricular surface.

(3) Back of sacro-tuberous ligament (p. 27).

Insertion : Mostly into deep fascia and ilio-tibial band. Lower deep fibres (say one-quarter of bulk of muscle) into bone—namely, gluteal ridge of femur.

Nerve supply : Inferior gluteal (L. 5, S. 1, 2).

Action: Extensor and lateral rotator of thigh; balances pelvis (and therefore trunk) on thigh (working with psoas and iliacus); through ilio-tibial band steadies femur at knee-joint in standing.

NOTE.—(1) Very coarse loose fasciculi of muscle.

(2) It covers the posterior part of gluteus medius, and the stout gluteal fascia covering this.

(3) Its lower border overlaps the tuberosity of the ischium (in standing) and the sacro-tuberous ligament, a bursa intervening.

(4) It covers all the short muscles round the hip-joint; the sciatic nerve lying on these; the upper ends of the hamstrings; and the two sciatic foramina with the structures passing through these.

(5) Its lower border does not correspond to the gluteal fold (which is an extension crease of the hip-joint like the flexion creases of the fingers).

Gluteus medius: *Arises* from the outer surface of the ilium below the crest and the posterior gluteal line, and above the middle gluteal line.

Insertion: Oblique line running diagonally forwards and downwards across outer aspect of great trochanter, and an area below this.

Nerve supply: Superior gluteal (L. 4, 5; S. 1).

Action: Abduction of thigh or tilting upwards of opposite side of pelvis; thus, in walking, the gluteus medius of the limb which is on the ground supports the pelvis and prevents it from tilting.

Gluteus minimus—Origin: The outer surface of the ilium between the middle and inferior gluteal lines.

Insertion: The front of the great trochanter of the femur.

Nerve supply: Superior gluteal (L. 4, 5, S. 1).

Action: Abductor and medial rotator of thigh, and in walking assists gluteus medius as described above.

Tensor fasciæ latæ: This is described here since it is derived from the gluteal muscles, is supplied by the superior gluteal nerve and its action is to assist the gluteus maximus in tightening the ilio-tibial band. (See action of gluteus maximus, above.)

Origin: Outer surface of ilium below anterior part

of iliac crest between tubercle of crest² and anterior superior iliac spine.

Insertion : Ilio-tibial tract

Nerve supply : Superior gluteal (L. 4, 5, S. 1).

4.—THE SHORT LATERAL ROTATORS OF THE THIGH

Piriformis : *Arises* within the pelvis from the front of the middle three pieces of the sacrum; leaves pelvis by great sciatic foramen.

Insertion : Pointed posterior extremity of upper border of great trochanter ("tip" of trochanter).

Nerve supply : Directly from 2nd and 3rd sacral nerves

Obturator internus : This also *arises* within the true pelvis from the obturator membrane, the bone around the obturator foramen and a large area behind and above the foramen. Tendon leaves pelvis by small sciatic foramen, a bursa beneath it, then bends at a right angle around edge of notch.

Insertion : Medial surface of great trochanter above trochanteric fossa.

Nerve supply : Special "nerve to obturator internus" (L. 5, S. 1, 2).

Gemelli : These are two slips of muscle *arising* from the upper and lower margins respectively of the small sciatic notch. They are *inserted* into the sides of the tendon of the obturator internus. They are detached portions of obturator internus, the action of which they reinforce.

The inferior is supplied by the nerve to quadratus femoris (see below), the superior by the nerve to obturator internus.

Quadratus femoris—*Origin* : From the outer border of the tuberosity of the ischium; fibres run horizontally outwards, forming small somewhat quadrilateral mass.

Insertion : Quadrate tubercle on upper part of trochanteric crest of femur and quadrate ridge running a short distance down from this.

Nerve supply : Special "nerve to quadratus femoris" (L. 4, 5; S. 1).

5.—THE HAMSTRING GROUP OF MUSCLES

These long muscles of the back of the thigh are flexors of the knee and extensors of the thigh. They are the **semitendinosus**, **semimembranosus** and **biceps**, and (except for the short head of the biceps) they arise from the tuberosity of the ischium. They are supplied by the sciatic nerve—the short head of biceps by the lateral popliteal (L. 5; S. 1), the others by the medial popliteal division (L. 5; S. 1).

The **semimembranosus** arises from the upper and lateral area on the back of the tuberosity of the ischium; the **semitendinosus** and **long head of the biceps** arise together from the lower and medial area. The upper part of the semimembranosus consists of a wide, thin tendon, which passes down deep to the other two.

The long head of the biceps passes laterally and downwards across the semimembranosus tendon to join the short head of the biceps in the lower part of the thigh. This **short head** of the biceps arises from the linea aspera and upper part of the lateral supracondylar ridge. The two heads join to form a tendon which is inserted into the lateral aspect of the head of the fibula in front of the styloid process and inferior to the lateral ligament of the knee.

The semimembranosus and semitendinosus run vertically down the medial aspect of the back of the thigh, the latter being superficial.

Insertion of semimembranosus : Primarily into a groove on back of medial tuberosity of tibia; extensions to oblique line of tibia (fascia over popliteus), to back of capsule of knee-joint (oblique posterior ligament), to bone beneath medial ligament (Fig. 33, p. 100).

Insertion of semitendinosus : Medial side of shaft of tibia behind sartorius and inferior to gracilis.

THE MUSCLES OF THE LEG

These consist of three groups: the **anterior or extensor group**, all supplied by the anterior tibial nerve; the **posterior or flexor group**, all supplied by

the posterior tibial nerve; and the **lateral peroneal** or **everter group**, supplied by the musculo-cutaneous nerve.

NOTE.—Owing to the fact that the fibula is on a plane posterior to the tibia the anterior compartment faces laterally as well as anteriorly.

The **deep fascia of the leg** forms a sheath for all these muscles and sends septa in between them; it is attached to the anterior border of the tibia, and sweeps right round the front, the lateral side and the back of the leg to reach the tibia again at its postero-medial border.

At the ankle it forms **retinacula** like those at the wrist, to hold the various tendons in place; there are four retinacula of the leg, which are described with the appropriate muscles.

I.—THE ANTERIOR OR EXTENSOR MUSCLES (ANTERIOR COMPARTMENT)

(All supplied by anterior tibial nerve.)

Tibialis anterior—*Origin* : Upper two-thirds lateral surface of tibia, and interosseous membrane.

Insertion : Medial and under part of 1st cuneiform and base of 1st metatarsal.

Action : Dorsiflexion (extension) and inversion of foot.

Extensor hallucis longus—*Origin* : Medial part of middle third of anterior surface of fibula and interosseous membrane.

Insertion : Base of terminal phalanx of great toe on dorsal aspect.

Action : Extension of great toe and dorsiflexion (extension) of foot.

Extensor digitorum longus—*Origin* : Upper two-thirds of anterior surface of fibula, lateral to extensor longus hallucis; interosseous membrane.

Insertion : By four tendons into the four lateral toes; each tendon is inserted into the bases of the middle and distal phalanges, as in fingers (p. 80).

The tendons to the 2nd, 3rd and 4th toes are reinforced by the extensor brevis digitorum (p. 103).

Action : Extension of toes and dorsiflexion of foot.

Peroneus tertius : Not really a peroneal muscle, but a part of the extensor longus digitorum.

Origin : Lower part of anterior surface of shaft of fibula in continuity with extensor longus digitorum.

Insertion : Dorsal aspect of base and shaft of 5th metatarsal.

Nerve supply : Note that this is the anterior tibial—i.e. the same as the other extensors, not as the peroneal muscles proper (p. 102).

Action : Dorsiflexes (extends) and everts foot.

Important relations of the anterior compartment muscles : The anterior tibial artery and anterior tibial nerve lie on the interosseous membrane—first between tibialis anterior and extensor longus digitorum, and then between tibialis anterior and extensor longus hallucis; they pass under the tendon of extensor longus hallucis at the level of the ankle-joint.

The extensor retinacula : Two bands, one above the ankle, the other in front of and below the ankle.

Superior retinaculum extends from upper part of fibular malleolus to shaft of tibia just above malleolus. Pierced by tibialis anterior tendon, other tendons pass beneath it.

Inferior retinaculum (lower band, Y-shaped ligament) extends from lateral part of calcaneum medially and splits, upper limb going to medial malleolus, lower to plantar aponeurosis. Pierced by all the tendons which are thereby slung to calcaneum.

The tendons pass down under these bands. The tibialis anterior has a synovial sheath extending under both retinacula; the extensor hallucis has a separate synovial sheath and the extensor digitorum and peroneus tertius have a common sheath under the lower band only.

2.—THE POSTERIOR OR FLEXOR GROUP

---MUSCLES OF THE CALF

(All supplied by medial popliteal nerve.)

These consist of a superficial group and a deep group.

The superficial group (gastrocnemius, plantaris and soleus) join to form the stout **tendo calcaneus**, which is inserted into the back of the calcaneum. The gastrocnemius and plantaris cross the back of the knee-joint and therefore flex this as well as the ankle.

THE SUPERFICIAL MUSCLES OF THE CALF

The **gastrocnemius** arises by two heads from the femur.

Origin—**Medial head**: From the back of the femur immediately above the medial condyle.

Lateral head: Upper part of lateral aspect of lateral condyle (note asymmetry of these two heads).

Insertion: Muscle fibres are replaced about half-way down the leg by **tendo-calcaneus** (Achillis), which is inserted into middle third of back of calcaneum. A bursa separates tendon from upper third of back of calcaneum.

Action: Flexor of ankle and of knee.

Soleus—*Origin*: (1) Upper fourth posterior aspect of fibula.

(2) Soleal (oblique popliteal) line of tibia and middle third of medial border of shaft of tibia.

(3) Fibrous arch over popliteal vessels.

Insertion: Deep aspect of **tendo-calcaneus**, and so to calcaneum.

Action: Flexor of ankle. Powerful multipennate muscle.

Plantaris: A small muscle with a very long tendon.

Origin: Lower part of lateral supracondylar ridge. Quickly forms long, thin tendon, passing downwards and medially over soleus and under gastrocnemius.

Insertion: Blends with medial part of **tendo-calcaneus**.

Action: Accessory to gastrocnemius, but the muscle is a rudiment in man of a large muscle of the toes in certain animals.

NOTE.—The superficial calf muscles, especially the soleus, have a special postural function in standing—namely, maintaining the balance of the body at the

ankle, acting, of course, in conjunction with the extensors.

THE DEEP MUSCLES OF THE CALF

These are a short muscle of the knee (the popliteus) and three muscles inserted into the foot.

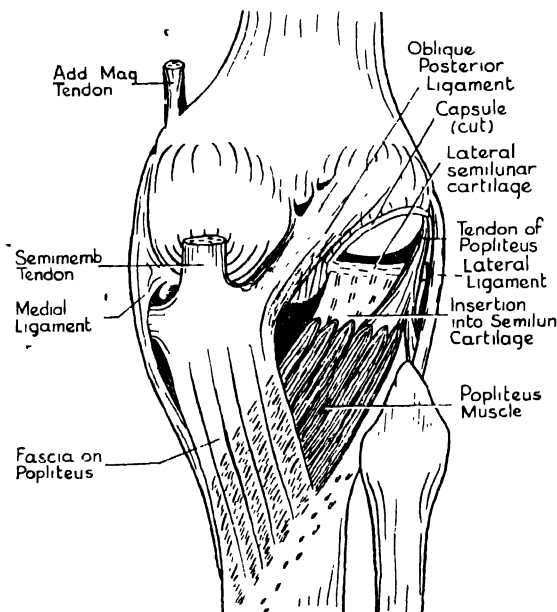


FIG. 33.—DISSECTION BEHIND RIGHT KNEE, TO SHOW INSERTION OF POPLITEUS INTO LATERAL MENISCUS.

The popliteus—*Origin* : Popliteal surface of tibia above soleal line.

Insertion : Lateral half of muscle by a round tendon into anterior end of popliteal groove on lateral femoral condyle. *Medial half of muscle by a flat*

aponeurosis into lateral meniscus and capsule of joint (Fig. 33).

Nerve supply : From medial popliteal, branch curves around lower border of muscle and enters deep surface.

Action : Rotates knee (femur laterally or tibia medially). Also controls position of lateral meniscus, protecting it from crushing between condyles of femur and tibia. Not a flexor of knee; as commonly stated.

Flexor longus hallucis—*Origin* : The lower three-quarters of the posterior surface of the fibula and the interosseous membrane. Large powerful multipennate muscle.

Insertion : The base of the terminal phalanx of the big toe.

Nerve supply : Posterior tibial (S. 1, 2).

Action : Naturally this muscle flexes the big toe, but its essential function is to raise the heel off the ground in walking, for the special point of support at the front of the foot is the ball of the big toe. Very important in maintaining medial longitudinal arch of foot (p. 43).

Note the relations of the tendon—namely, very deep at ankle, grooving the talus and the under surface of the sustentaculum tali; and running forwards in the sole to cross above (deep to) the tendon of the flexor digitorum longus, to which it gives a slip.

Flexor digitorum longus—*Origin* : The medial half of the back of the tibia below the oblique soleal line and from fibula. It is a bipennate muscle.

Insertion : Into the four outer toes. Each tendon is inserted into the base of the distal phalanx after splitting flexor brevis digitorum tendons, identical with arrangement in hand.

Action : Flexion of the toes, and elevation of the heel. *Supplied* by posterior tibial nerve (S. 1, 2).

Tibialis posterior—*Origin* : (1) The lateral half of the back of the tibia below the soleal line.

(2) The upper two-thirds of the medial surface of the fibula.

(3) The interosseous membrane.

Insertion † Primarily into the tuberosity of the navicular. From this insertion slips pass:

(a) Backwards to the sustentaculum tali.

(b) Laterally to the cuboid, lateral cuneiforms and bases of the 2nd, 3rd and 4th metatarsals

(c) Forward to the 1st cuneiform and base of the 1st metatarsal.

Action: Flexion and inversion of the foot. With the foot on the ground, the muscle is an important support of the longitudinal arch of the foot. Its tendon lies directly alongside the spring ligament (see p. 41). *Supplied* by posterior tibial nerve (L. 4).

NOTE.—The posterior tibial vessels and nerve lie superficial to tibialis posterior, between flexor hallucis longus and digitorum longus.

The **flexor retinaculum** extends from the tibial malleolus to the medial margin of the back of the calcaneum; it covers the three deep tendons (which lie in synovial sheaths) and the posterior tibial vessels and nerve.

3.—THE PERONEAL OR EVERTOR GROUP

This comprises two muscles on the lateral aspect of the leg—the peroneus longus and brevis; both arise from the lateral surface of the fibula.

Peroneus longus—**Origin**: Upper two-thirds of lateral aspect of shaft of fibula. Tendon lies on peroneus brevis behind lateral malleolus, crosses calcaneo-fibular ligament, passes *below* peroneal tubercle, lies in groove of cuboid and crosses sole of foot obliquely. Sesamoid fibro-cartilage or bone in tendon where it bears on cuboid.

Insertion: Lateral aspect of 1st metatarsal and of base of 1st cuneiform (*cf.* tibialis anterior, p. 97).

Nerve supply: Musculo-cutaneous (L. 5; S. 1), which nerve pierces the upper part of the muscle.

Actions: Eversion and flexion (plantar flexion) of foot. If foot is on the ground it steadies the leg, and helps in supporting the transverse arch of the foot.

Peroneus brevis: Lies anterior to longus.

Origin: Lower two-thirds of lateral aspect of

fibula, overlapping lower part of peroneus longus, which lies behind it.

Insertion : Styloid process of base of 5th metatarsal. Tendon lies in front of peroneus longus on back of lateral malleolus and above peroneal tubercle on lateral aspect of calcaneum.

Nerve supply : Musculo-cutaneous (L. 5; S. 1).

Action : Everts and plantar flexes foot.

Peroneal retinacula and synovial sheaths : The peroneal tendons are invested by a common sheath on the back of the lateral malleolus. As they separate to take up their respective positions above and below the peroneal tubercle (Fig. 17, p. 39), each carries its own sheath forwards from the common sheath. Small loops of fibrous tissue above and below the tubercle form retinacular tunnels for the tendons with their sheaths.

THE MUSCLES OF THE FOOT

These are short muscles, whose origin and insertion are entirely within the foot.

DORSUM OF THE FOOT

The extensor digitorum brevis—*Origin* : From the upper surface of the anterior process of the calcaneum. It forms a fleshy mass partly under cover of the inferior extensor retinaculum (p. 98).

Insertion : By four tendons into the four medial toes. The tendon to the great toe (extensor brevis hallucis) is inserted independently into the base of the proximal phalanx; those to the 2nd, 3rd and 4th toes join the common extensor expansion (see p. 97).

Nerve supply : Lateral terminal branch of anterior tibial on its deep surface.

THE MUSCLES OF THE SOLE OF THE FOOT

These are best described in four layers from the surface inwards; the most superficial structure in the sole is the *plantar aponeurosis*, a thickened, deep fascia, closely resembling the similar layer in the palm (p. 84).

The **plantar aponeurosis** consists of a thick, strong central part, which is attached posteriorly to the medial tubercle of the calcaneum, and thinner parts on each side which form the ordinary deep fascia covering the muscles. The central portion spreads out as it passes forwards, and splits into five digitations, one to each toe, which blend with the sheaths of the flexor tendons of the toes (*cf.* the palmar aponeurosis).

FIRST OR SUPERFICIAL LAYER OF MUSCLES

These are the **abductor hallucis**, the **abductor digiti minimi** and the **flexor digitorum brevis**.

Origin : The three muscles arise from the front of the tubercles of the calcaneum. The **abductor hallucis** is medially placed, and also arises from the flexor retinaculum; the **abductor digiti minimi** arises from the lateral tubercle, but extends on to the medial tubercle deep to the abductor hallucis; the **flexor digitorum brevis** arises from the medial tubercle only, superficial to the abductor digiti minimi.

Insertions : The **abductor hallucis** is inserted into the medial side of the base of the proximal phalanx (through a sesamoid bone; *cf.* hand, p. 85).

The **abductor digiti minimi** is inserted into the lateral side of the base of the proximal phalanx of the little toe; some fibres are inserted into the base of the 5th metatarsal.

The **flexor digitorum brevis** tendons split over the flexor digitorum longus tendons to go to the margins of the 2nd phalanx of each of the four lateral toes (*cf.* flexor digitorum sublimis, p. 77).

Nerve supply :

Abductor hallucis	} Medial plantar nerve
Flexor brevis digitorum	
Abductor minimi digiti	Lateral plantar nerve
	(S. 1, 2).

Actions : As named. Help to maintain longitudinal arch.

SECOND LAYER OF MUSCLES OF THE FOOT

These are the **flexor digitorum accessorius** and the **lumbricals**, both muscles being associated with the tendons of the **flexor digitorum longus**, which tendons, together with the tendon of the **flexor hallucis longus**, lie in this layer—i.e. immediately under the **flexor digitorum brevis**.

Flexor digitorum accessorius—*Origin*: By two heads:

Medial head (muscular) from hollow surface of calcaneum under sustentaculum tali.

Lateral head (smaller and tendinous) from under surface of calcaneum in front of lateral tubercle and from long plantar ligament (p. 42).

Insertion: Upper (deep) surface of tendons of **flexor digitorum longus**.

Nerve supply: Lateral plantar (S. 1, 2).

Actions: Flexes terminal phalanges when belly of long flexor is shortened in plantar-flexion of foot. May also correct line of pull of long flexor tendons.

Lumbricals: Four very slender muscles arising from adjacent sides of tendons of **flexor longus digitorum**, except first, which is from medial side of first tendon.

Insertions: Into extensor expansions on dorsum of lateral four toes passing to tibial side of each toe (cf. lumbricals of hand, p. 86).

Nerve supply: 1st (unipital), by medial plantar nerve; 2nd, 3rd and 4th (bicipital), by lateral plantar nerve.

Actions: Prevent terminal phalanges from buckling under by pull on them of **flexor digitorum longus**—i.e. they straighten the toes.

THIRD LAYER OF MUSCLES OF THE FOOT

Flexor hallucis brevis—*Origin*: (1) Tendon of **tibialis posterior** (forward extension from navicular).

(2) By oblique tendinous slip from under surface of cuboid.

Insertion: By two slips to medial and lateral

sesamoid bones of great toe, and so to sides of proximal phalanx.

Nerve supply: Medial plantar nerve.

Adductor hallucis—*Origin*: By two heads—transverse and oblique:

***Transverse head**: From ligaments of plantar aspect of metatarso-phalangeal joints of 3rd, 4th and 5th toes.

Oblique head: (1) From sheath of peroneus longus. (2) From bases of 2nd, 3rd and 4th metatarsals.

Insertion: Through lateral sesamoid into lateral aspect of base of proximal phalanx of great toe.

Nerve supply: Deep branch of lateral plantar nerve.

Flexor digiti minimi brevis—*Origin*: Base of 5th metatarsal and sheath of peroneus longus

Insertion: Lateral aspect of base of proximal phalanx.

**Nerve supply*: Lateral plantar nerve (superficial division).

FOURTH LAYER OF MUSCLES OF THE FOOT

These are the dorsal (4) and plantar (3) interossei. They closely resemble those of the hand, but are classified in relation to their actions relative to the *second* toe (contrast *third* finger).

The four **dorsal interossei** abduct from line of second toe, and therefore the first and second act on the second toe.

Origins: From the adjacent sides of the metatarsals in each intermetatarsal space.

Insertions: **First**, medial side of base of proximal phalanx of 2nd toe.

Second, lateral side of base of proximal phalanx of 2nd toe.

Third, lateral side of base of proximal phalanx of 3rd toe.

Fourth, lateral side of base of proximal phalanx of 4th toe.

The three **plantar interossei** adduct, and therefore none can be inserted into the 2nd toe.

Origins : Medial sides of 3rd, 4th and 5th metatarsals.

Insertions : Medial sides of bases of proximal phalanges of same toes.

Nerve supply : Lateral plantar nerve to all interossei (deep division to medial three spaces, superficial division to fourth space).

THE MUSCLES OF THE ABDOMINAL WALL

The abdominal wall (Fig 34) consists principally of three sheets of muscle, which are fleshy at the sides

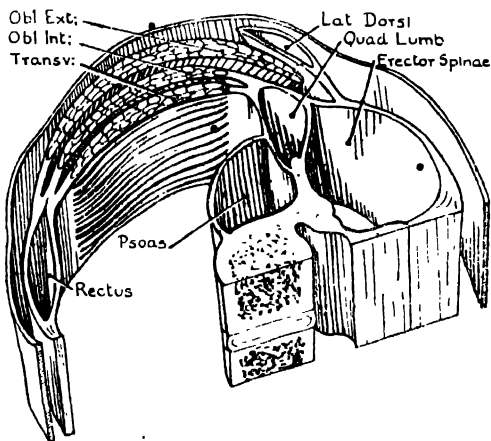


FIG. 34 —DIAGRAM OF THE RIGHT HALF OF THE ABDOMINAL WALL SEEN FROM WITHIN.

The obliques and transversus muscles are shown, but the other muscles are represented by the fascial spaces containing them

but aponeurotic in front and behind; they are the **external oblique**, **internal oblique** and **transversus** from without inwards. In addition, there is a wide vertical muscle on either side of the midline in front—the **rectus abdominis**. As the aponeuroses pass forwards they

ensheath the rectus; in the lower part of this sheath is a small accessory muscle, the **pyramidalis**. Posteriorly the abdominal wall is completed by the **quadratus lumborum**, between the last rib and the iliac crest; and the **psaos** (p. 87), also enters into the posterior abdominal wall near the vertebral column.

Actions of the abdominal muscles: The general actions of these muscles are compression of the abdominal viscera in expulsive efforts—defecation, micturition, parturition. In addition they flex the trunk as a whole, and act also as muscles of expiration.

The external oblique—*Origin*: The outer surfaces of the lower eight ribs by slips, the upper of which interdigitate with the serratus anterior and the lower with the latissimus dorsi (pp. 67 and 70).

Insertion: (1) The most posterior fibres extend downwards to a muscular insertion into the anterior half of the iliac crest.

(2) The rest of the muscle, directed downwards and forwards, ends in an aponeurosis which is attached—

(a) To the anterior superior iliac spine.

(b) To the pubic tubercle and crest.

Between these two points the lower border of the aponeurosis is folded in and thickened to form the **inguinal ligament** (Poupart), to which is attached the deep fascia of the thigh.

(c) To its fellow of the opposite side in the mid-line forming the fibrous **linea alba**, which extends from the xiphisternum above to the symphysis pubis below.

Action: See above.

Nerve supply: Lower six thoracic nerves.

NOTE.—The **linea alba** is formed, not only by the external oblique aponeurosis, but by the aponeuroses of the internal oblique and transversus (see below), all three blending in the mid-line.

The **inguinal ligament** (Poupart's ligament) bridges across the femoral sheath, femoral nerve, psoas and iliacus as these pass from the abdomen into the thigh. A deep extension of the ligament to the ilio-pectineal line is the **lacunar ligament**. The **reflected part** goes

from pubic tubercle up across midline and forms a "posterior crus" for opposite muscle.

The **superficial inguinal ring** (external abdominal ring) is a triangular opening in the external oblique aponeurosis situated above the pubic crest. It is the external opening of the inguinal canal (p. 112), transmitting the spermatic cord (male), round ligament of uterus (female) and ilio-inguinal nerve.

Note *three* free borders of external oblique muscle:

1. Posterior, fleshy, a boundary of lumbar triangle.
2. Inferior, aponeurotic (inguinal ligament).
3. Superior, upper border of rectus sheath, from 5th rib to sternum. Pectoralis major arises from this aponeurosis.

The **lumbar triangle** lies above iliac crest between external oblique and latissimus dorsi. Floored in by internal oblique.

The **internal oblique** (Figs. 34, 35) (and **cremaster**)—*Origin*: (1) Posteriorly it arises by lumbar fascia from the transverse processes of the lumbar vertebrae.

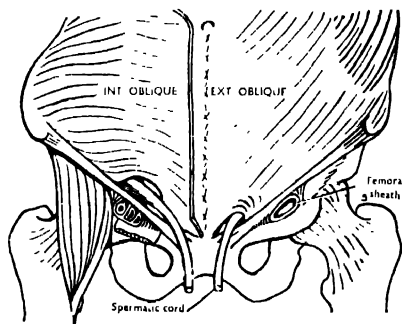


FIG. 35.—THE INGUINAL CANAL.

On the left side the canal is intact. On the right side the canal has been opened up by removing the external oblique.

- (2) The anterior two-thirds of the iliac crest.
- (3) The lateral two-thirds of the inguinal ligament.

Fibres are directed forwards and upwards.

Insertion : (1) By muscular fibres into lower borders of lower six costal cartilages.

(2) By aponeurotic sheet :

(a) Blending in mid-line with fellow of opposite side (linea alba).

(b) Attached above to xiphisternum.

(c) Attached below to pubic crest and ilio-pectineal line by **conjoined tendon** common to it and transversus

(3) The lowest fibres form loops around the cord, constituting a separate supporting muscle, known as the **cremaster**—found in the male only.

Action : See p. 108.

Nerve supply : Lower six thoracic and first lumbar (ilio-hypogastric and ilio-inguinal). Cremaster by genital branch of genito-femoral nerve (L. 2).

Transversus abdominis—*Origin* : (1) Deep surfaces of lower six costal cartilages interdigitating with diaphragm.

(2) Posteriorly it arises by lumbar fascia from transverse processes of lumbar vertebræ.

(3) Anterior two-thirds medial lip of iliac crest and iliac fascia.

(4) Lateral one-half of inguinal ligament.

Fibres run horizontally forwards.

Insertion : By aponeurotic sheet :

(1) Joining its fellow of opposite side in mid-line.

(2) Attached above to xiphisternum

(3) Attached below to pubic crest and ilio-pectinea line by **conjoined tendon** common to it and internal oblique.

Action : See p. 108.

Nerve supply : Lower six thoracic and ilio-hypogastric and ilio-inguinal nerves.

Neuro-vascular plane : On the deep surface of the internal oblique, between this and the transversus, lie the nerves and vessels of the abdominal wall, passing forward to the rectus.

NOTE.—The **transversalis fascia** is a thin layer lining the inner surface of the transversus muscle. It is continuous with the general layer of fascia

lining the posterior abdominal wall.* In the inguinal region it becomes continuous across the back of the inguinal ligament with the iliac fascia; but where the femoral vessels pass into the thigh they carry the transversalis fascia with them as the anterior layer of the **femoral sheath**, the posterior layer coming from the iliac fascia.

Boundaries of inguinal canal (Fig. 35)—*Posterior wall*. Transversalis fascia laterally and conjoined tendon medially.

Anterior wall: External oblique aponeurosis, reinforced in lateral part by origin of internal oblique from inguinal ligament.

Roof: Fibres of internal oblique and transversus arching across to conjoined tendon

Floor: Inverted edge of inguinal ligament.

Entrance: **Deep inguinal ring** in transversalis fascia. Medial side of ring reinforced by **interfoveolar ligament**, looping down from transversus muscle to inguinal ligament. Ring lies above midpoint of inguinal ligament; inferior epigastric artery lies to its medial side.

Exit: **Superficial inguinal ring** in external oblique aponeurosis. Crura slope down to pubic tubercle and symphysis. Laterally reinforced by intercrural fibres at right angles to those of external oblique aponeurosis.

The rectus abdominis—*Origin*: (1) **Medial head**, tendinous, from front of body of pubes close to symphysis. (2) **Lateral head**, muscular, from top of crest of pubis.

Insertion: Anterior aspect of 5th, 6th and 7th costal cartilages. Lower border of 7th.

NOTE.—The two recti diverge a little at their upper ends, and become thinner and wider than below.

Nerve supply: The lower six intercostals.

Actions: The rectus flexes the pelvis on the trunk, or the trunk on the pelvis. In particular it steadies the pelvis when the foot is off the ground, as in walking; when the lower limb is thrust forward it would rotate the front of the pelvis downwards, were this not prevented by the rectus.

Rectus sheath (Fig. 34) and **tendinous intersections**: As the aponeurotic sheets of the two obliqui and the

transversus pass forwards to the mid-line they have to cross the rectus muscle, and are so disposed to it as to form the sheath of the rectus. The internal oblique aponeurosis splits at the lateral edge of the rectus into two laminae—one in front of the rectus and one behind; the transversus aponeurosis fuses with the posterior layer, and the external oblique aponeurosis with the anterior. In about the lower fourth of the rectus, however, all three aponeuroses pass in front, thus leaving the sheath deficient behind with a crescentic free margin, the arcuate line (semilunar fold of Douglas). The fused aponeuroses in the mid-line between the recti constitute the *linea alba*.

The anterior layer of the sheath is attached to the muscle by irregular transverse **tendinous inter-sections**, which dip at intervals into the substance of the rectus. These are usually three in number: one about the level of the umbilicus, one at the xiphisternum, and one between these.

Note that the space within the sheath and in front of the rectus thus consists of several compartments, but behind the rectus of one long undivided compartment.

The **pyramidalis** is a small triangular muscle inside the rectus sheath, in front of the lower part of the rectus

Origin : Crest of pubis.

Insertion : Linea alba

Nerve supply : 12th thoracic.

Action : Tightens the linea alba.

The quadratus lumborum—*Origin* : (1) Posterior quarter of inner lip of iliac crest.

(2) Upper border of ilio-lumbar ligament (p. 27).

(3) Tips of transverse processes of lower two or three lumbar vertebræ.

Insertion : (1) Medial half of inferior border of 12th rib.

(2) Tips of transverse processes of upper two or three lumbar vertebræ.

Nerve supply : 2nd and 3rd lumbar; branches straight from lumbar anterior primary rami.

Actions : (1) Lateral flexor of vertebral column.

- (2) Fixator of last rib for action of diaphragm during inspiration.

Lies in anterior compartment of lumbar fascia (p. 62).

THE MUSCLES OF THE CHEST WALL.

(Fig. 36, and Fig. 54, p. 271.)

Morphology of thoracic wall: Three muscular layers seen in abdominal wall (p. 107) become specialised in thorax.

1. External oblique represented by pectoralis major and minor, serratus anterior, rhomboids, levator scapulæ.

2. Internal oblique represented by intersegmental bony condensations (*i.e.* ribs) with intervening muscle specialised into two layers, internal and external intercostals.

3. Transversus abdominis represented by dome of diaphragm (and levator ani) and intracostal muscles (p. 115).

NOTE.—Neurovascular plane lies between (2) and (3) in both thorax and abdomen.

In ventral mid-line three layers fuse into longitudinal rectus abdominis and, in neck, geniohyoid and infrahyoid muscles. (Note segmental supply from spinal nerves.) Posteriorly (1) and (2) become extensor muscles of spine (p. 61) supplied by posterior primary divisions and (3) becomes pre-vertebral rectus, represented by longus capitis, longus cervicis, crura of diaphragm, psoas major and minor, piriformis (supplied by anterior primary divisions).

The external intercostals—*Origin*: Outer border of subcostal groove of rib above.

Insertion: Fibres directed downwards and forwards to upper border of rib below.

Extent of muscle: From superior costo-transverse ligament to costo-chondral junction, there replaced up to sternum by **external (anterior) intercostal membrane**.

Nerve supply: Corresponding intercostal nerves by collateral bronchas.

Action : Elevate ribs for inspiration.

The internal intercostals—Origin : The floor of the subcostal groove of the rib above.

Insertion : Fibres directed downwards and backwards to the upper border of the rib below.

Extent of muscle : From side of sternum to posterior angle of rib, there replaced to superior costo-transverse ligament by internal (posterior) intercostal membrane.

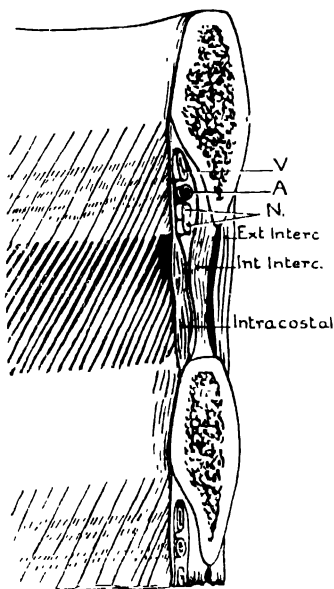


FIG. 36.—THE THREE MUSCLE LAYERS OF THE INTERCOSTAL SPACES AND THE NEURO-VASCULAR PLANE.

Nerve supply : Corresponding intercostal nerves by collateral branches.

Action : Anteriorly, raise ribs for inspiration; more posteriorly depress ribs for expiration.

Intracostal layer of muscles: Cross more than one intercostal space *within* the ribs, found in three main situations:

Intercostales intimi—*Origin*: Medial border of subcostal groove of rib above (membranous).

Insertion: May cross a rib or two, finally blending with internal intercostal at upper border of a rib.

Nerve supply: Corresponding intercostal nerves.

Action: As internal intercostals.

Transversus thoracis (Sterno-costalis) -- *Origin*: Deep aspect of xiphoid, of lower part of gladiolus sterni, and of 5th, 6th and 7th costal cartilages.

Insertion: Fibres radiate upwards and laterally to backs of 2nd to 6th costal cartilages.

Nerve supply: Intercostal nerves.

Action: Raises xiphisternum (*i.e.* weak inspiratory effect).

Subcostals: Long, ill-defined slips extending over several ribs and lining postero-lateral part of chest wall.

Levatores costarum: Eleven small muscles, each arising from the tip of a transverse process and inserted into upper border of rib below, near angle. Posterior fibres of scalenus medius are in series.

Nerve supply: Each by its corresponding intercostal nerve (*posterior, not anterior* primary division).

THE DIAPHRAGM

This is a double-domed sheet separating the thorax from the abdomen. It consists of a central trilobed tendinous sheet, attached to the edge of which are muscular fibres. These muscle fibres complete the septum, and are attached peripherally all round the body wall; they are described as taking origin from the body wall and insertion into the margin of the central tendon.

Origin: (1) Posterior fibres (*a*) by right and left **crura**, from fronts of upper lumbar vertebræ (three on right side, two on left); (*b*) from the medial and lateral arcuate ligaments (Fig. 71, p. 369).

(2) Lateral fibres, from the inner surfaces of the

lower six costal cartilages, interdigitating with the transversus (p. 116).

(3) Anterior fibres, small slips, from back of xiphisternum.

Insertion: Each part arches high to be inserted into the adjacent part of the edge of the central tendon.

Nerve supply: Phrenic (C. 4). Crura by spinal nerves.

Actions: (1) Principal muscle of inspiration; the muscular fibres depress each dome and so increase the vertical diameter of the chest.

(2) Pushes down abdominal viscera and thus aids in increasing intra-abdominal pressure in expulsive efforts—e.g. defæcation, micturition, labour.

NOTE.—Openings in diaphragm: (1) *Inferior vena cava* and fibres of right phrenic nerve—right leaf of central tendon—opposite 8th thoracic vertebra. Pulled open when diaphragm contracts, aiding venous return.

(2) *Œsophagus*: Through left crus, slung in muscular loop from right crus—opposite 10th thoracic vertebra. Transmits gastric nerves (i.e. vagi) and œsophageal vessels (artery, veins, lymphatics) from left gastric vessels. Closed by muscular fibres when diaphragm contracts.

(3) *Aorta*: Under tendinous margins of crura—opposite 12th thoracic vertebra. Does not open through diaphragm, passes *behind* it, so unaffected when diaphragm contracts. Transmits vena azygos and thoracic duct.

Splanchnic nerves pass through crura, sympathetic trunks behind medial arcuate ligament. Lower intercostal nerves pass between digitations into neurovascular plane of anterior abdominal wall. Left phrenic nerve pierces left dome.

THE MUSCLES OF THE PELVIS

Two of these muscles—the **levator ani** and the **coccygeus**—are limited to the pelvis. Two others line the pelvic wall—the pyriformis on the front

of the sacrum, and the obturator internus on the lateral wall of the true pelvis; these two muscles, however, act on the femur, and are described with the muscles of the lower limb (p. 95).

The levator ani muscles, arising from the side wall of the pelvis, are thin sheets of muscle which meet in the mid-line and close the greater part of the outlet of the pelvis (posterior or rectal part of pelvic diaphragm).

Origin: (1) Back of body of pubis.

(2) Spine of ischium.

(3) Between these, from fascia covering obturator internus along a thickening between the above two points ("white line").

Insertion: (1) Into side of coccyx, overlapping pelvic surface of coccygeus and into median raphe of perineum—i.e. fibrous tissue at meeting of two muscles in mid-line (ilio-coccygeus and pubo-coccygeus).

(2) Into sides of rectum where this passes between the two muscles (pubo-rectalis).

(3) Into sides of prostate in male (levator prostatae), and of vagina in female (sphincter vaginae or pubo-vaginalis).

Nerve supply: Perineal branch of S. 4 on pelvic surface and inferior hæmorrhoidal and perineal on perineal surface.

Actions: (1) Muscles as a whole form diaphragm of pelvic outlet, supporting pelvic viscera and resisting downward pressure of abdominal muscles.

(2) They form special constrictors of rectum and vagina.

Coccygeus: A small triangular muscle behind, and in the same plane as the levator ani.

Origin: Spine of ischium.

Insertion: Side of coccyx and lowest part of sacrum. The muscle thus has the same attachments as the sacro-spinous ligament (p. 27), with which it is partly blended.

Nerve supply: Perineal branch of S. 4.

Action: The two muscles hold the coccyx in its natural forward inclination.

Pelvic fascia: *Parietal pelvic fascia* is a strong mem-

brane covering muscles of pelvic walls, attached to bone at margins of muscles.

Visceral pelvic fascia is loose and cellular over movable structures (levator ani, distensible bladder and rectum), strong and membranous over fixed or non-distensible structures (prostate, base of bladder). Between latter and rectum is recto-vesical fascia.

THE MUSCLES OF THE PERINEUM

NOTE.—Anatomically the perineum consists of the superficial tissues of the outlet of the pelvis; it therefore includes the anal region and the urogenital region. Clinically the term perineum implies only the urogenital part of the above.

MUSCLES OF THE ANAL CANAL

Anal canal: $1\frac{1}{2}$ inches long, extends from ano-rectal junction at levator ani (pubo-rectalis, p. 117, to ano-cutaneous junction at exterior). Two sphincters:

Internal sphincter: Unstriated muscle, surrounds upper two-thirds of anal canal; a thickening of circular coat of rectum, supplied by sympathetic nerves (pelvic plexus). Incompetent alone, but assists external sphincter.

External sphincter: Striated muscle, surrounds lower two-thirds anal canal. Is not a ring, but three rings that make a tube of muscle. Deepest ring fused posteriorly with pubo-rectalis, called *profundus* part of sphincter; nerve is inferior hæmorrhoidal. Middle ring is *superficialis*, attached behind to coccyx, in front to central point of perineum; nerve is perineal branch of S. 4. Third ring, *subcutaneous*, is unattached, lies beneath peri-anal skin; supplied by inferior hæmorrhoidal. Most important part is ano-rectal ring, formed by profundus and pubo-rectalis. Is essential to continence of fæces and flatus.

Ischio-rectal fossa: Space between anal canal and side wall of pelvis (fascia over obturator internus, condensed around pudendal vessels and nerve to

form pudendal canal). Roof is perineal (lower) surface of levator ani, hence fossa has prolongation forwards over sphincter urethræ on each side of membranous urethra. The space contains loose fat; infection here causes ischio-rectal abscess, which may burst into anal canal.

MUSCLES OF THE UROGENITAL REGION
OF THE PERINEUM: MUSCLES SUPERFICIAL
TO THE PERINEAL MEMBRANE

The bulbo-spongiosus is a thin sheet covering the corpus spongiosum in the male.

Origin : Central tendinous point of perineum and ventral mid-line raphé.

Insertion : Into aponeurosis on dorsum of penis, some fibres encircling corpus spongiosum only, and others encircling the corpora cavernosa as well.

Action : Compresses bulbous part of urethra at end of micturition. Empties urethra.

This muscle is represented in the female by the **sphincter vaginae**, which encircles the vagina and in front of this, the corpus spongiosum of the clitoris.

Action : Sphincter of the orifice of the vagina.

Nerve supply : Of male and female muscles—perineal.

The ischio-cavernosus is a thin slip covering the corpus cavernosum on each side.

Origin : Medial aspect of ramus of ischium.

Insertion : Sides of corpus cavernosum.

Nerve supply : Perineal.

Action : Compresses crus during erection.

The same muscle in the female is attached to the crus clitoridis.

Superficial transversus perinei—*Origin* : Medial surface of ramus of ischium, behind ischio-cavernosus.

Insertion : Central tendinous point of perineum.

MUSCLES DEEP TO THE PERINEAL
MEMBRANE

These are the **sphincter urethræ membranaceæ** and the **deep transversus perinei**—which form the

urogenital diaphragm (compare rectal diaphragm, p. 117).

Sphincter urethræ membranaceæ—*Origin* : Edge of pubic arch in region of junction of pubis and ischium.

Insertion : Fibres meet fellow of opposite side in front of and behind urethra, some are not attached to bone, but encircle the urethra.

Nerve supply : Perineal branch of pudendal (S. 2, 3, 4).

Action : Can maintain urinary continence in absence of vesical sphincter.

Deep transversus perinei : Consists of isolated posterior fasciculi of the sphincter urethræ membranaceæ.

Origin : Ramus of ischium behind sphincter membranaceæ.

Insertion : Blends with fellow of opposite side in fibrous raphé.

Nerve supply : Perineal of pudendal

Action . Supporter of central part of perineum.

The Vascular System

THE HEART

The **heart** is a hollow muscular organ enclosed in the pericardium, and having an irregular conical shape. It is attached at its base to the great bloodvessels, being otherwise free within the pericardial sac.

Position: The heart is placed obliquely, the base being directed upwards, backwards, and to the right; the apex downwards, forwards, and to the left.

Surface Markings of the Heart (Fig. 37, p. 122)

Superior: Line from lower border of 2nd left to upper border of 3rd right costal cartilage.

Inferior: Line from 6th right sterno-costal articulation to apex

Right side: Line drawn nearly vertically $1\frac{1}{2}$ inches from mid-line of sternum, from 3rd to 6th costal cartilages.

Left side: Line from lower border of 2nd left costal cartilage, 1 inch from sternum, downwards and to the left to apex.

The *apex* corresponds to a point in the 5th left intercostal space $3\frac{1}{2}$ inches from the mid-line.

Position of the Valves (Fig. 37)

Pulmonary: Behind upper border of 3rd left costal cartilage near sternum.

Aortic: Behind left half of sternum, on level with lower border of 3rd costal cartilage.

Tricuspid: Extends obliquely from mid-line at level of 4th costal cartilage down to junction of 6th cartilage with sternum.

Mitral: Opposite junction of 4th left costal cartilage with sternum.

Divisions : The heart is divided longitudinally by a vertical septum which lies in almost the *coronal* plane. Atria divided from ventricles by *atrio-ventricular groove*, which lies in almost *sagittal* plane. Right atrium lies *in front of* left atrium, right ventricle *in front of* left ventricle.

Atrio-ventricular fibrous ring separates muscle of

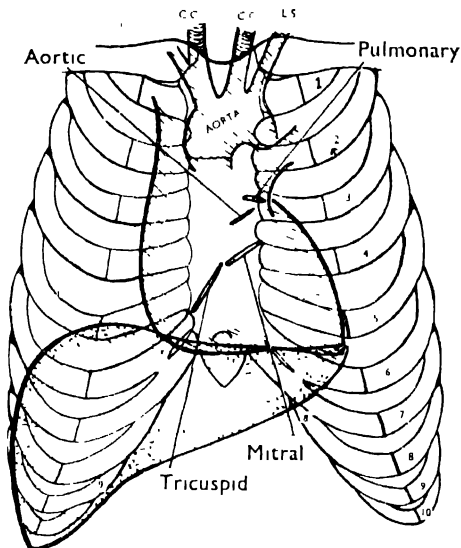


FIG. 37.—OUTLINE OF CHEST WALL FROM FRONT TO SHOW SURFACE MARKINGS OF HEART, GREAT VESSELS, VALVES, AND LIVER.

atrium from that of ventricle. Two rings joined (right in front of left) to make figure of 8; membranous part of interventricular septum is attached to line of junction.

The circulation : The right atrium receives venous blood from the *venæ cavæ* and coronary sinus; thence blood passes into the right ventricle, whence it is con-

veyed to the lungs by the pulmonary trunk. After passing through the lungs, the blood enters the left atrium by the pulmonary veins; thence it is conveyed into the left ventricle, and from there to the aorta, whence it passes through the body.

THE CAVITIES OF THE HEART (Figs. 38 to 41)

The **right atrium** consists of a principal cavity and an auricle.

The principal cavity is of an irregular form and is smooth-walled.

The *auricle* is a small muscular pouch projecting to the left from the anterior and upper angle of the atrium overlapping the ascending aorta and the root of the pulmonary trunk. Its interior is marked by parallel muscular ridges (*musculi pectinati*).

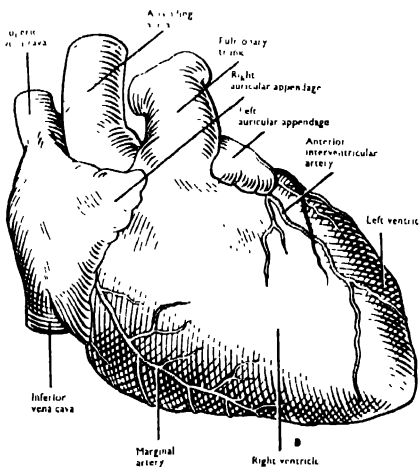


FIG. 38.—THE ANTERIOR SURFACE OF THE HEART.

At the junction externally of the two cavities is seen a groove (*sulcus terminalis*), which on the interior appears as a ridge (*crista terminalis*).

Openings: *Superior vena cava*, in the upper part; *inferior vena cava*, at the lower part of the atrium. Between the openings of the two cavæ is a muscular projection, the *intervenous tubercle*.

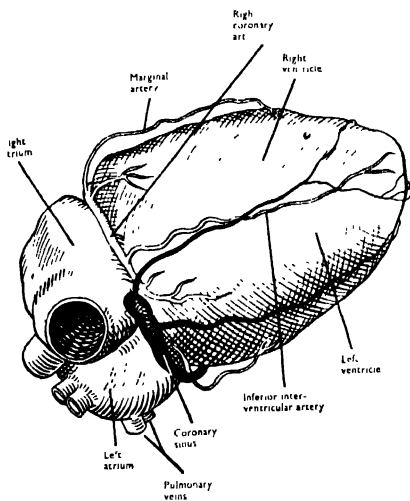


FIG. 39.—THE DIAPHRAGMATIC SURFACE OF THE HEART.

The *coronary sinus* opens between the inferior vena cavæ and the atrio-ventricular orifice.

Foramina venarum minimarum are the mouths of *venæ cordis minimæ*.

The *atrio-ventricular orifice* is in front of the inferior vena cava.

Valves: The *valve of the inferior vena cava* (*Eustachian valve*) is a semilunar fold of endocardium in front of the anterior margin of the inferior vena cava;

passes upwards and to the left to anterior margin of the annulus ovalis.

The *valve of the coronary sinus* (*Thebesian valve*) protects the opening of the coronary sinus.

Remnants of fetal structures: The *fossa ovalis* is a depression on the interatrial septum, above the opening of the inferior vena cava (Fig. 41).

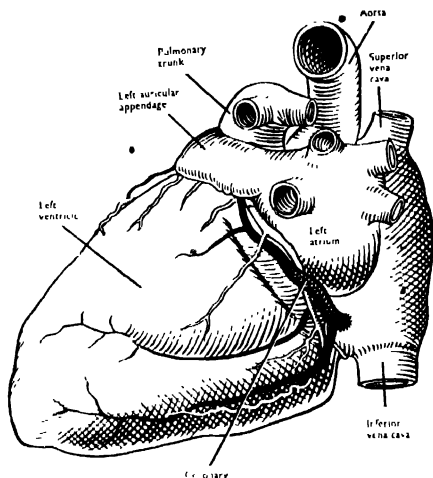


FIG. 40. —THE HEART VIEWED FROM BEHIND.

The *anulus ovalis* is the upper crescentic elevated margin of the fossa.

The *foramen ovale* in the foetus (sometimes in the adult) pierces the upper part of the floor of the fossa ovalis and opens into the left atrium.

The **right ventricle** consists of a cavity, the upper angle of which is prolonged into a funnel-shaped canal, the *infundibulum*, leading to the pulmonary trunk. On the wall (except in the infundibulum, which is smooth) are projections, *trabeculae carneae*

formed of muscular bundles, of which there are three varieties: The first are merely prominent ridges. The second are attached at the ends, being free in the middle of these, one, the *septo-marginal (moderator) band*, extends from the septum to the base of the anterior papillary muscle; it may assist in preventing over-distension of the ventricle, and it conducts the right branch of the atrio-ventricular bundle to the anterior wall of the ventricle. The third are the

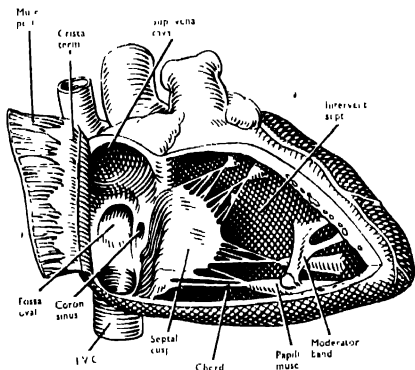


FIG. 41.—THE INTERIOR OF THE RIGHT ATRIUM AND VENTRICLE.

papillary muscles (anterior, inferior and septal) which project inwards, and are attached by their bases to the wall of the ventricle, the other end being connected with the *chordæ tendineæ*, or cords attached to the flaps of the atrio-ventricular valve (Fig. 41).

The *tricuspid (atrio-ventricular) valve*, which guards the right atrio-ventricular orifice, consists of three cusps, formed by a reduplication of the endocardium, with some fibrous tissue enclosed. The bases of the flaps are attached to the fibrous ring of the atrio-ventricular orifice, while to their free edges and ventricular surfaces are attached the *chordæ tendineæ*.

Position of cusps: Anterior, inside sterno-costal

surface of ventricle. *Septal*, on membranous part of interventricular septum, lies posterior. These two are equal in size. Smaller *inferior* cusp lies on diaphragmatic wall of ventricle. The valve prevents regurgitation of blood into the atrium during ventricular contraction.

The opening of the *pulmonary trunk* is at the summit of the funnel-shaped *infundibulum*, and is guarded by the pulmonary semilunar valves. The semilunar valves are three fibrous folds, a *right*, *left*, and *posterior*, which guard the orifice of the pulmonary trunk. The free margin of each has in its middle a small fibrous nodule, the *nodule of pulmonary valve*, and between each valve and the beginning of the pulmonary trunk is a dilatation called the pulmonary sinus.

The **left atrium** consists of a principal cavity and an *auricle*; the latter extends forwards and to the right, overlapping the commencement of the pulmonary trunk; its interior presents muscular ridges as on the right side.

Openings : The four *pulmonary veins* open into the cavity, two from either lung, superior and inferior.

The *atrio-ventricular orifice* is smaller than that on the right side.

On the septum may be seen a shallow depression, the remains of the *foramen ovale*.

The **left ventricle** is longer and more conical than the right, with its walls nearly three times as thick. The interior contains trabeculæ carneæ, papillary muscles (superior and inferior), and chordæ tendineæ, as on the right side.

Openings : The *atrio-ventricular orifice* is closed by the *mitral valve*, which is attached to the circumference of the opening, similarly to the tricuspid. It consists of two flaps, the larger being anterior (*aortic cusp*).

The *aortic opening* is placed in front and to the right side of the preceding. The orifice is guarded by three semilunar valves, which are precisely similar to those on the pulmonary artery, the characteristics of which are, however, better marked; they are named

from their position *anterior, right and left posterior*.

The **endocardium** is the endothelial membrane lining the whole of the interior of the heart and is continuous with the lining membrane of the blood vessels.

The **coronary arteries** supply the substance of the heart.

The *right coronary artery* comes off from the anterior aortic sinus, passes on the right side of the pulmonary trunk, between it and the right auricle, then downwards, then backwards along the right atrio-ventricular groove as far as the inferior interventricular groove, where it divides into two branches, one of which runs on in the left atrio-ventricular groove and joins branch of left artery, while the other passes to the left in the inferior interventricular groove to supply the ventricles and septum; *anas. descending branch of left artery*.

The *left coronary artery* arises from the left posterior aortic sinus. It passes behind and then to the left of the pulmonary artery, and divides into two branches, one of which passes forwards and downwards in the anterior interventricular groove, and the other to the left and backwards along the left atrio-ventricular groove. Anastomoses between coronary arteries and their interventricular branches are through terminal *arterioles*.

The **cardiac veins** return the blood from the muscular wall mainly through the coronary sinus into the right atrium (Fig. 40).

Great cardiac vein : From apex, up anterior interventricular groove to base of ventricles, curving to left side and back part of heart, empties into coronary sinus; guarded by two valves; receives left marginal and left cardiac veins.

Middle cardiac vein : From apex up posterior (*i.e.* inferior) interventricular groove, terminating in coronary sinus, guarded by valves.

Small cardiac : The marginal vein, running with the artery along inferior border of right ventricle, usually ends in the anterior cardiac vein, but may join coronary sinus.

The **coronary sinus** is the terminal part of the great

cardiac vein which is placed in the left atrio-ventricular groove. Is 1 inch in length, and ends in the right atrium, the opening being guarded by the valve of the coronary sinus. Receives tributaries as above, and a small straight vein at the back of the left atrium, the *oblique vein of left atrium*, the remnant of the left superior vena cava of the fœtus.

Anterior cardiac vein: Drains sternó-costal surfaces of right atrium and ventricle, opens directly into right atrium. Usually receives small cardiac vein. It and *venæ cordis minimæ* do not empty via coronary sinus, which thus carries only 60 per cent. of venous drainage of myocardium.

Venæ cordis minimæ: Drain muscular substance, opening into right atrium.

Conducting system: *Sinu-atrial node* lies astride right auricular appendage. Large ill-defined area, containing autonomic plexus and nerve cells (vagus relay). *Atrio-ventricular node* lies in interatrial septum just above opening of coronary sinus; small and discrete. *Conducting bundle* (of His) from A-V node crosses atrio-ventricular fibrous septum and membranous part of interventricular septum. Branches to right and left along interventricular muscle septum to walls of ventricles.

THE PERICARDIUM

FIBROUS PERICARDIUM

The heart and roots of great arteries and veins are contained in a fibrous bag, conical in shape. Apex attached around great vessels about 2 inches from heart, base fused with central tendon of diaphragm. It lies in middle mediastinum. Sensory supply from phrenic and anterior intercostal nerves.

Relations of fibrous pericardium—Anterior: Sternum and left costal cartilages (4 to 7), remains of thymus, anterior edges of lungs and pleuræ.

Posterior: Œsophagus, descending aorta, thoracic vertebræ (5 to 8).

Lateral: Lungs, roots of lungs, phrenic nerves.

SEROUS PERICARDIUM

Fibrous pericardium is lined by *parietal* layer of serous pericardium; this is reflected to cover heart and roots of great vessels, the serous pericardium here being called *visceral* layer. At the reflections veins surrounded by one sleeve arteries by another sleeve of serous pericardium; between the venous and arterial reflections embryonic dorsal mesocardium has broken down to produce *transverse sinus* of pericardium. Pulmonary veins become separated to leave *oblique sinus* of pericardium between them. In front of transverse sinus lie aorta and pulmonary trunk, behind it lie superior vena cava and left atrium. Left atrium separates transverse and oblique sinuses. Sensory supply of parietal layer by phrenic nerve. Visceral layer insensitive. (Compare peritoneum and pleura.)

THE ARTERIES OF THE BODY

THE PULMONARY TRUNK

The **pulmonary trunk** conveys de-oxygenated blood from the right side of the heart to the lungs. It is 2 inches long and, commencing at the infundibulum of the right ventricle, is directed upwards in front of the ascending aorta, and in same tube of serous pericardium; it then passes upwards and backwards on the left of the ascending aorta to reach the concavity of the aortic arch, where it divides in front of the left bronchus into right and left branches for the lungs. Near the bifurcation a fibrous cord, the *ligamentum arteriosum*, passes from the left branch to the under surface of the aortic arch. It is the remains of the *ductus arteriosus* in the foetus. Three-quarters of trunk within fibrous pericardium, terminal half-inch bifurcates outside fibrous bag.

Branches: The **right pulmonary artery** is longer than the left, passes in front of œsophagus to the root of the right lung, behind the ascending aorta and superior vena cava, where it divides into three primary branches, one for each lobe.

The **left pulmonary artery** is connected at origin with the arch of the aorta by the ligamentum arteriosum, and passes in front of the descending aorta and left bronchus to the root of the left lung, there dividing into two primary branches for the two lobes.

THE AORTA (Figs. 37, 42)

Large main trunk of systemic arteries, situated partly in thorax and partly in abdomen, commences

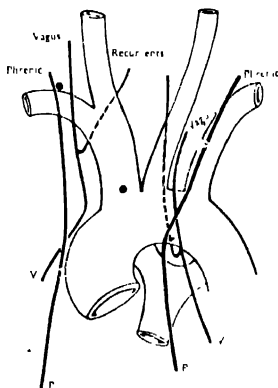


FIG. 12 --AORTIC ARCH, VIEWED SOMEWHAT FROM LEFT SIDE, SHOWING ORIGINS OF GREAT VESSELS AND RELATIONS OF VAGUS AND PHRENIC NERVES TO THESE AND THE ARCH.

at left ventricle, arches over root of left lung, descends in front of vertebral column, behind diaphragm into abdomen, ending opposite left side of body of 4th lumbar vertebra by bifurcating into two common iliacs. Conveniently divided into four parts: *ascending aorta*, *arch of aorta*, *descending thoracic aorta*, *abdominal aorta*.

Ascending aorta (Fig. 38, p. 123) — *Extent and course*: Two inches in length. Extends from base of left ventricle, opposite lower border of 3rd left costal cartilage, upwards and to the right to level

of 2nd right costal cartilage. At its root it presents three bulgings, the *sinuses of aorta*, one above each aortic cusp. With pulmonary trunk makes a spiral in common tube of serous pericardium in front of transverse sinus.

Branches: The right and left coronary arteries (p. 128).

Arch of aorta: Lies wholly in superior mediastinum and occupies *antero-posterior* plane (seen in profile in A.P. X-ray). Commences at sternal angle, convex upwards and to left as it crosses left side of 4th thoracic vertebra.

In the concavity of the arch are contained root of left lung, branching of pulmonary trunk with ligamentum arteriosum, cardiac plexuses, left recurrent laryngeal nerve, œsophagus and thoracic duct.

Relations

<i>Anterior and to Left.</i>	<i>Superior.</i>	<i>Inferior.</i>	<i>Posterior and to Right</i>
Manubrium.	Left innominate vein	Bifurcation of pulmonary trunk.	Trachea
Thymus		Ligamentum arteriosum.	Deep cardiac plexus.
Left pleura and lung.		Left bronchus.	œsophagus.
Left phrenic		Left recurrent laryngeal nerve.	Thoracic duct.
Inferior cardiac of left		Superficial cardiac plexus.	Left recurrent laryngeal nerve.
vagus			
Cardiac of left superior cervical ganglion			
Left vagus			
Left superior intercostal vein.			

Branches

BRACHIO-CEPHALIC (INNOMINATE) (1½ to 2 inches long): Arises at commencement of transverse part, ascends to right beneath sternum, dividing behind right sterno-clavicular articulation into *right common carotid* and *right subclavian* arteries (see pp. 134 and 146).

Relations of the innominate: Lies behind manubrium and origins of right sterno-hyoid and sterno-thyroid muscles, thymus gland and left brachio-cephalic (innominate) and right inferior thyroid veins. Trachea at first behind, but to left side above, where

artery lies on pleura. On the right side lie the right innominate vein and right phrenic nerve. On the left side is the left common carotid below, the trachea above. The innominate occasionally gives off a branch, the *arteria thyroidea ima*, which passes in front of trachea to thyroid gland.

LEFT COMMON CAROTID (see p. 135)

LEFT SUBCLAVIAN: Arises behind left common carotid, ascends to neck in contact with apex of left lung, over which it arches. *Relations* in thorax as those of left common carotid (p. 135).

THE DESCENDING THORACIC AORTA

Extent: From lower border of 4th thoracic vertebra (left side) to aortic opening in front of body of 12th thoracic vertebra.

Course and Relations: Lies in posterior mediastinum; is at first to left of bodies of vertebræ, but afterwards lies in front of them.

Anterior: Root of left lung, pericardium and diaphragm; crossed by œsophagus at lower end.

Posterior: Bodies of vertebræ and hemiazygos veins, superior and inferior.

Left side: Left lung and pleura.

Right side: Oesophagus above, thoracic duct, and vena azygos; right lung and pleura in lower part but not in actual contact.

Branches

Bronchial: Supply the bronchial tree. For the left lung two branches come off from front of aorta (superior and inferior). The artery supplying right lung arises either with or from superior left branch, or from first right aortic intercostal.

Pericardial: Small twigs to posterior surface of pericardium.

Oesophageal (4 or 5): From front of aorta, running obliquely downwards to supply œsophagus; *anas.* with one another, inferior thyroid and left gastric.

Mediastinal: Supply glands, etc., of posterior mediastinum.

Posterior intercostal (9 pairs): Arise from posterior part of aorta, run transversely outwards on bodies of vertebræ, and behind pleura to lower nine intercostal spaces. The right ones, crossing over front of spine, supply the bodies of vertebræ, and pass behind œsophagus, thoracic duct, and azygos veins. The arteries of both sides are crossed by sympathetic trunk and its splanchnic branches. On reaching intercostal spaces they divide into anterior and posterior branches; the *anterior* branch crosses the space obliquely upwards so as to get to lower border of the upper rib near the angle; passes forward in intercostal space in neurovascular plane—i.e. between internal intercostal and transversus thoracis group of muscles (p. 113); *anas.* intercostal of internal mammary, thoracic branches of axillary. Above the artery is a companion vein, and below the intercostal nerve. A branch, the *collateral intercostal*, is given off near the angle of the rib, and runs along the upper border of the lower rib; *anas.* intercostal of internal mammary. Branches accompany the lateral cutaneous nerves of the thorax from the main trunks of the intercostals. The three lower branches pass forwards between muscles of abdominal wall; *anas.* epigastric and lumbar.

The *posterior* branch passes backwards between vertebra and superior costo-transverse ligament, sending medially *spinal* branch through intervertebral foramen to cord, membranes and body of vertebra, and backwards *muscular* branch, which divides into medial and lateral branches to muscles and skin of back.

Subcostal arteries (corresponding to *intercostal* below 12th rib): Pass into abdomen behind lateral arcuate ligament and follow lower border of 12th rib.

The 1st and 2nd intercostal arteries come from costo-cervical branch of subclavian (p. 152).

THE ARTERIES OF THE HEAD AND NECK

THE COMMON CAROTID ARTERY

THE COMMON CAROTID ARTERY: On the right side, arises from the innominate at its bifurcation behind

the right sterno-clavicular articulation.) On the left side, from the highest part of aortic arch; the left is consequently longer than the right artery, and is deeply placed in the thorax at its origin. It ascends obliquely to the neck.

Relations

Left Common Carotid in the Thorax

Anterior.	Medial.	Lateral.
Left innominate vein.	Trachea.	Left subclavian artery (also posterior).
Remains of thymus.	Esophagus.	
Overlapping pleura and lung.	Thoracic duct.	Left vagus and phrenic nerves.
	Left recurrent laryngeal nerve.	Left pleura and lung.
	Innominate artery.	

Both Common Carotids in the Neck

Extent : In the neck the common carotid of either side extends from sterno-clavicular articulation to level of upper border of thyroid cartilage (third cervical vertebra) there dividing into external and internal carotids.

Course : A line drawn from sterno-clavicular articulation to a point midway between mastoid process and angle of mandible.

Relations of Both Common Carotids in the Neck

Crossed about midway by omo-hyoid, and enclosed in same condensation of cervical fascia as internal jugular vein and vagus nerve.

Anterior.	Posterior.	Medial.
Skin.	Scalenus anterior.	Trachea and larynx.
Superficial fascia.	Longus capitis.	Pharynx and esophagus.
Platysma.	Longus cervicis.	Recurrent laryngeal nerve.
Cervical fascia (investing layer).	Inferior thyroid artery.	Thyroid body.
Sterno-mastoid (sternal origin).	Vertebral artery.	Superior thyroid artery.
Sterno-hyoid.	Sympathetic.	
Sterno-thyroid.	Recurrent laryngeal.	
Omo-hyoid.	Vagus.	
Sterno - mastoid branch of superior thyroid artery.		

BRANCHES OF THE COMMON CAROTID ARTERY: Terminal only—viz., external and internal carotid. As the common carotid divides, it widens; this dilatation, the carotid sinus, extends upwards into the internal carotid artery; its wall is thinner than elsewhere, and has many nerve filaments from the glosso-pharyngeal, vagus and sympathetic (pressor receptors). * *

EXTERNAL CAROTID—Extent: From bifurcation of common carotid opposite upper border of thyroid cartilage to level of neck of mandible, there (embedded in the parotid gland) dividing into superficial temporal and maxillary. Carries sympathetic fibres from cell bodies in superior cervical ganglion.

in the latter dilatation the carotid sinus can be easily felt, contained in the Relations carotid sinus

Superficial.			Deep.		
Skin.	Facial	} Veins	Pharynx.		} Nerves.
Superficial fascia.	Lingual		Styloid process.	Stylo-mandibular	
Platysma.	Posterior		Stylo-glossus.	ligament.	
Cervical fascia.	facial		Stylo-pharyngeus.	Superior laryngeal	
Sterno-mastoid	} Muscles	} Nerves	Glosso-pharyngeal nerve.	External laryngeal	} Nerves.
Digastric				Pharyngeal	
Stylo-hyoid			Internal carotid artery.	branch of vagus.	
Parotid gland.					

Anterior branches of External Carotid

Superior thyroid: Given off just below greater horn of hyoid, curves downwards and forwards to upper pole of thyroid gland; *anas.* fellow of opposite side, inferior thyroid.

Branches

- ① **Muscular:** To muscles covering it. **Sterno-mastoid branch** passes downwards and laterally across sheath of common carotid, supplying sterno-mastoid and skin.
- ② **Infrahyoid:** Runs transversely along inferior border of hyoid; *anas.* with opposite fellow.
- ③ **Superior laryngeal:** Accompanies internal laryngeal nerve, pierces thyro-hyoid membrane, supplies muscles, glands, and mucous membrane of pharynx and larynx down to vocal folds; *anas.* opposite fellow and inferior laryngeal.

Crico-thyroid : Accompanies external laryngeal nerve. Crosses crico-vocal membrane transversely; *anas.* opposite fellow.

⑤ *Thyroid* : Terminal division takes place within pre-tracheal fascia, into one anterior and two posterior branches (*cf.* inferior thyroid artery, p. 149).

✓ *Lingual* : Arises from anterior part of artery between superior thyroid and facial arteries; loops upwards and forwards on middle constrictor to tip of greater horn of hyoid, where it is crossed by hypoglossal nerve; thence forwards under hyoglossus, parallel with hypoglossal nerve, crossing stylo-hyoid ligament; finally on genioglossus upwards and forwards to tip of tongue as profunda artery of tongue.

Branches

✓ *Suprahyoid* : Along superior border of hyoid, supplying muscles, etc.; *anas.* opposite fellow.

Dorsales linguae : Two or three, ascend to dorsum of tongue; *anas.* opposite fellows, supply mucous membrane, tonsil, epiglottis, soft palate, etc.

Sublingual : Runs forwards and laterally to supply sublingual gland, adjacent muscles, and mucous membrane.

Profunda artery of tongue : Continuation of the lingual to tip of tongue, accompanies lingual nerve.

✓ *Facial* : Arises near angle of mandible, directed forwards and upwards on superior constrictor beneath digastric in groove on deep surface of submandibular gland to body of mandible, thence downwards between gland and mandible, finally around inferior border of mandible, over which it ascends to face, being anterior to masseter muscle. It ascends tortuously to medial angle of orbit, where it terminates by anastomosing with dorsalis nasi of ophthalmic. It rests successively upon mandible, buccinator, and levator anguli oris, with vein posteriorly, and is crossed by platysma, risorius, zygomaticus major, and usually by the levator labii superioris.

Cervical branches

Ascending palatine : Ascends between stylo-glossus

and stylo-pharyngeus to pharyngeal recess, where it pierces pharyngo-basilar fascia, supplies muscles, tonsil, pharyngo-tympanic tube, soft palate, glands, etc.; *anas.* tonsillar and artery of opposite side.

Tonsillar: Penetrates superior constrictor of pharynx to supply tonsil and root of tongue; *anas.* ascending palatine.

Glandular (three or four): To supply submandibular gland.

Submental: Arises as artery turns round base of mandible, and runs forwards over mylo-hyoid, supplying it and digastric, then to symphysis, there dividing into *superficial*, which turns round chin (*anas.* inferior labial and mental), and a *deep* branch which perforates mylo-hyoid, supplying floor of mouth and sublingual gland (*anas.* sublingual).

Facial branches

Muscular: To masseter, buccinator, etc.

Inferior labial: Arises near angle of mouth; tortuous course between mucous membrane of lower lip and orbicularis oris; *anas.* freely with opposite fellow.

Superior labial: Arises with or near preceding, having corresponding course in upper lip; *anas.* with opposite fellow, supplies a branch to the septum of nose.

Lateral nasal: Turns medially beneath levator labii superioris aequae nasi to supply ala and dorsum of nose; *anas.* opposite fellow, nasal of ophthalmic, and infra-orbital.

Posterior branches of external carotid

Occipital: Arising from the posterior part of artery, opposite the facial, runs upwards and backwards beneath digastric and mastoid process with its attached muscles; then backwards in the occipital groove, and lying on rectus capitis lateralis, obliquus capitis superior and semispinalis capitis; lastly, crossing the border of the trapezius near insertion, it ascends in company with the greater occipital nerve to the back of scalp. The artery crosses the internal carotid artery, accessory nerve, and internal jugular vein, and is crossed by the hypoglossal nerve which loops round it.

Branches

Muscular : To digastric, stylo-hyoid; *sterno-mastoid* branch to supply that muscle (guide to accessory nerve).

Mastoid : Through mastoid foramen to dura mater.

Meningeal. Ascends, in company with internal jugular vein, through jugular foramen to dura mater in posterior fossa

Descending branch : At lateral border of semispinalis capitis; descends at back of neck; *superficial branch* passes beneath splenius, supplying it and the trapezius, *anas.* superficial branch of transverse cervical; *deep branch* goes beneath semispinalis capitis, *anas.* vertebral, deep cervical of costo-cervical trunk.

Occipital : To muscles and skin of occiput; *anas.* opposite fellow, posterior auricular and superficial temporal

Posterior auricular : Arises opposite apex of styloid process, ascends in parotid to groove between auricle and mastoid process, dividing into *anterior* or *auricular*, *anas.* posterior division of temporal; and *posterior* or *mastoid*, *anas.* occipital. Joined near mastoid process by posterior auricular branch of the facial nerve.

Branches

Stylo-mastoid : Enters stylo-mastoid foramen, supplying tympanum, mastoid cells, etc. Stapedial artery is remnant of artery of second pharyngeal arch.

Auricular : To posterior part of concha.

Ascending branch of external carotid :

Ascending pharyngeal : Smallest branch, arising $\frac{1}{2}$ inch above origin of trunk, ascends, deep to internal carotid and stylo-pharyngeus and lying on pharynx, to base of skull.

Branches

Prevertebral : To prevertebral muscles and lymph-glands.

Pharyngeal (three or four): Medially to pharynx, supplying constrictors, pharyngo-tympanic tube, and a *palatine* branch to soft palate and tonsil.

Meningeal¹: One through jugular foramen, another through anterior condylar canal, and a third through foramen lacerum to supply dura mater.

Inferior tympanic: Passes through inferior tympanic canaliculus with tympanic branch of glosso-pharyngeal nerve to supply medial wall of tympanum and anastomose with other tympanic arteries.

Terminal branches of external carotid

Superficial temporal: Smaller of two terminal branches, continues in the line of external carotid. Imbedded at first in parotid, crosses over root of zygoma in front of auriculo-temporal nerve, upwards under skin for 2 inches, dividing into two terminal branches—anterior and posterior.

Branches

Parotid: To gland.

Transverse facial: Arises in parotid, accompanies transverse branches of facial nerve and parotid duct across face, lies above the duct, supplying muscles, glands, etc.; *anas.* facial, infra-orbital.

Middle temporal: Arises just above zygoma, perforates temporal fascia, supplying muscle makes vertical groove on squama; *anas.* deep temporal.

Zygomatic: Along zygoma between layers of temporal fascia to lateral angle of orbit

Auricular: To anterior portion of external ear; *anas.* posterior auricular.

Anterior temporal: One of terminal branches; follows line of junction of hair and face; *anas.* frontal, supra-orbital.

Posterior temporal: Runs upwards to vertex; *anas.* posterior auricular, occipital.

Maxillary: Arises in parotid, at first (mandibular portion) curving forwards between mandible and speno-mandibular ligament, parallel with auriculo-temporal nerve and lying on medial pterygoid muscle and inferior dental nerve; then (pterygoid portion) forwards and laterally on lateral (frequently on medial) surface of lower head of lateral pterygoid; finally (pterygo-palatine portion) enters pterygo-

palatine fossa between two heads of origin of lateral pterygoid.

Branches from Mandibular Portion

Anterior tympanic: Enters squamo-tympanic fissure, supplies tympanum and membrana tympani; generally gives off *deep auricular* to external auditory meatus; *anas.* artery of pterygoid canal, stylo-mastoid.

Middle meningeal: Arises between sphenomandibular ligament and neck of mandible, passes under lateral pterygoid between two roots of auriculotemporal nerve, through foramen spinosum of the sphenoid, dividing on great wing of sphenoid into anterior and posterior branches: anterior going to anterior inferior angle of parietal, posterior to squamous of temporal; anas. opposite fellow, meningeal of ophthalmic and ascending pharyngeal.

NOTE.—The anterior branch of the middle meningeal artery is liable to be torn in fractures of the vault, which commonly pass through the thin part of the skull where this artery lies. Note also that the meningeal arteries supply the diploe of the bones of the vault.

The middle meningeal gives off branches to trigeminal ganglion. *Superior petrosal:* Enters hiatus for greater superficial petrosal nerve; *anas.* stylo-mastoid of posterior auricular. *Orbital:* Through superior orbital fissure to orbit. *Superior tympanic:* Along canal for tensor tympani muscle.

Accessory meningeal: Through foramen ovale, supplies trigeminal ganglion and dura mater. (Generally a branch of the middle meningeal.)

Inferior dental: Descends with and behind inferior dental nerve through mandibular canal supplying teeth and gums, divides opposite first bicuspid into *incisive* and *mental*, the former going to incisor teeth, the latter coming out through mental foramen; *anas.* submental, inferior labial, mandibular. *Mylohyoid branch*, given off as artery enters foramen, runs in mylohyoid groove to medial pterygoid muscle. *Accessories* mylohyoid.

② *Lingual branch* accompanies lingual nerve.

Branches from pterygoid portion

Deep temporal (2) : Anterior and posterior to temporal fossa between muscle and cranium; *anas.* other temporal, lacrimal through foramina in zygomatic bone.

• **Pterygoid :** To pterygoid muscles.

Masseteric : Passes over mandibular notch to deep surface of masseter; also supplies mandibular joint.

Buccal : Runs forwards with buccal nerve between medial pterygoid and jaw to buccinator; *anas.* facial.

Branches of pterygo-palatine portion

Posterior superior dental : Given off as artery passes into pterygo-palatine fossa; descends on posterior aspect of maxilla with branch of maxillary nerve; branches enter posterior dental canals, supplying molars, bicuspid, antrum, gums, etc.

Greater palatine : Through greater palatine canal with greater palatine nerve; and then along hard palate in a groove lateral to the nerve, and through lateral incisive foramen; *anas.* artery of septum from facial, and posterior septal.

Lesser palatine : Through lesser palatine foramina to muscles and mucosa of soft palate

Artery of pterygoid canal : Through pterygoid canal with nerve, supplies pharyngo-tympanic tube and tympanum.

Spheno-palatine : Enters spheno-palatine foramen, supplying posterior ethmoidal cells, etc. **Branch :** **Posterior septal,** runs along vomer; *anas.* greater palatine.

Infra-orbital : Continuation of trunk; accompanies infra-orbital nerve through infra-orbital canal, appearing on face beneath levator labii superioris, *anas.* facial and buccal. In the canal it gives off branches to orbit, and an **anterior dental** branch goes with nerve to supply front teeth; *anas.* posterior dental. On the face it supplies lacrimal sac and medial angle of orbit; *anas.* ophthalmic; and gives branches downwards; *anas.* transverse facial, buccal and facial.

INTERNAL CAROTID—Extent : From superior border of thyroid cartilage to base of brain, there dividing

into anterior and middle cerebral. Carries sympathetic fibres from cell bodies in superior cervical ganglion.

Relations in the Neck

<i>Superficial.</i>	<i>Medial.</i>	<i>Posterior.</i>
Skin.	Pharynx.	Internal jugular vein
Superficial fascia.	Ascending pharyngeal	at base of skull.
Platysma.	artery	Longus capitis.
Cervical fascia.	Superior and external	Sympathetic.
Sterno-mastoid.	laryngeal nerves.	Vagus.
Parotid gland.		
Digastric.		
Stylo-hyoid.		
Stylo-glossus		
Stylo-pharyngeus.		
Occipital	arteries.	
Posterior auricular		
Hypoglossal	nerves.	
Glosso-pharyngeal		
Pharyngeal branch of vagus		

Lateral.

Internal jugular vein at origin.

Course : Extends directly upwards from common carotid to carotid canal of temporal bone; entering canal passes upwards, medial to and then above pharyngo-tympanic tube, then forwards and medially, and again ascends to pass along the cavernous sinus, having the abducent nerve on the lateral side; it turns upwards medial to anterior clinoid process, pierces dura mater, passes back on roof of cavernous sinus and divides between optic and oculo-motor nerves below anterior perforated substance into branches. No branch is given off from cervical part.

Branch from petrous portion

Carotico-tympanic : Through foramina in carotid canal to tympanum; *anast.* anterior tympanic of maxillary and stylo-mastoid.

Branches from cavernous portion :

Hypophyseal : Small branches to hypophysis, etc.

Anterior meningeal : To dura mater in middle fossa and trigeminal ganglion.

Ophthalmic : Arises after internal carotid has pierced the dura mater at medial side of anterior clinoid process, enters orbit through optic foramen,

lateral to and below optic nerve; it then crosses over nerve to supero-medial angle of orbit to divide into two terminal branches, supra-trochlear and dorsalis nasi.

Branches arising lateral to optic nerve

Lacrimal : Accompanies lacrimal nerve over lateral rectus to lacrimal gland; gives off zygomatic branches; *anas.* deep temporal and transverse facial. Branch sent back to *anas.* with middle meningeal through superior orbital fissure.

Arteria retinae centralis : Pierces optic nerve; runs in its substance to retina (see p. 316). An end artery.

Branches arising on optic nerve

Posterior ciliary : Divided into two sets. *Short* perforate sclera and supply choroid. *Long* (2) pass forward between choroid and sclera; *anas.* anterior ciliary and supply iris and ciliary processes.

Supra-orbital : Ascends with frontal nerve over muscles, etc., to pass through supra-orbital notch; ascends over frontal bone; *anas.* temporal, facial and frontal.

Branches arising medial to optic nerve

Muscular, superior and inferior : To muscles of orbit, give off **anterior ciliary** (6-8), which pierce sclera behind cornea.

Ethmoidal : *Anterior* and *posterior* to ethmoidal cells, through anterior and posterior ethmoidal foramina respectively, supplying also dura mater; the anterior accompanies external nasal branch of anterior ethmoidal nerve (p. 243) to skin of nose (*anterior nasal branch*).

Medial palpebral (2) : One for each lid, arise near pulley, form an arch in each lid, and supply lacrimal apparatus.

Terminal branches

Supra-trochlear : Turns upwards round medial margin of orbit; *anas.* supra-orbital.

Dorsalis nasi : Over medial palpebral ligament to root of nose; *anas.* nasal and facial.

Branches from cerebral portion of internal carotid

Anterior cerebral : Arises at medial extremity of lateral cerebral fissure, passes forwards and medially across anterior perforated substance, above optic nerve; here united with opposite artery by *anterior communicating*; passes round genu of corpus callosum in longitudinal fissure. *Branches :* *Antero-medial* : central to anterior perforated substance. *Cortical* : Branches to orbital surface of frontal lobe, medial surface of hemisphere as far back as parieto-occipital sulcus, overlapping supero-medial border for 1 inch.

Middle cerebral : Largest branch, enters lateral cerebral fissure, dividing into branches for external surface of hemisphere, and interior of brain, the latter entering anterior perforated substance. *Branches :* *Striate* : To thalamus and corpus striatum, "artery of cerebral hæmorrhage." *Cortical* : Distributed to insula, opercula and lateral surfaces of frontal, parietal and temporal lobes to within 1 inch of their borders.

Posterior communicating : From posterior part of artery, runs backwards; *anas.* posterior cerebral of basilar to complete arterial circle

Anterior Choroid : From deep aspect of artery, passes backwards and laterally to enter inferior horn of lateral ventricle, just beneath edge of temporo-sphenoidal lobe; supplies hippocampus, fimbria, and choroid plexus.

THE BASILAR ARTERY : Formed by union of the two vertebral arteries (see p. 148). *Extent :* From lower to upper border of pons, there dividing into posterior cerebrals.

Branches

Pontine (4 or 6) : Twigs to supply pons.

Internal auditory : An offset to internal ear, with auditory nerve. Often arises from anterior inferior cerebellar.

Anterior inferior cerebellar : Backwards to anterior part of inferior surface of cerebellum; *anas.* posterior inferior cerebellar of vertebral.

Superior cerebellar : Arises near termination, passes laterally below oculo-motor nerve to wind round cere-

bral peduncle with trochlear nerve and basal vein (p. 179), and supplies upper surface of cerebellum; *anas.* opposite fellow, inferior cerebellar.

Posterior cerebral (2): One on each side, terminal of basilar, winds backwards round crus above oculomotor nerve, passes upwards to under surface of occipital lobes, joined near peduncle by posterior communicating, and gives off: *Postero medial* central to posterior perforated substance *posterior choroid* to choroid plexus through choroid fissure, *postero-lateral* central to thalamus and internal capsule, *i.e.* *thalamo-striate*, another "artery of cerebral hæmorrhage." *Cortical branches*: Temporal, calcarine, parieto-occipital. Supplies whole of occipital lobe, inferior temporal gyrus, inferior surface of temporal lobe except operculum (middle cerebral), *anas.* anterior and middle cerebral.

CIRCULUS ARTERIOSUS (circle of Willis): A name given to the anastomoses between the vertebral and internal carotid arteries at base of brain in the interpeduncular cistern; encloses optic chiasma and pituitary stalk. The internal carotid sends forward the anterior cerebrals, which are connected by the anterior communicating. The basilar sends forward the posterior cerebrals, which are joined to the carotid by the posterior communicating arteries.

THE SUBCLAVIAN ARTERIES

Extent: *Right*, from innominate opposite right sterno-clavicular articulation. *Left*, from convexity of arch of aorta (p. 133). Each passes into neck, arching laterally over pleura; lying on 1st rib, between scalenus anterior and medius, to end at lateral border of rib.

Divisions: The scalenus anterior, passing anteriorly to artery, divides it into three parts—viz.:

1st part, from origin of vessel to medial border of scalenus anterior.

2nd part, portion posterior to scalenus anterior

3rd part, from lateral edge of scalenus to lateral border of 1st rib.

**RELATIONS OF 1ST PART OF RIGHT
SUBCLAVIAN**

<i>Anterior</i>		<i>Inferior.</i>	<i>Posterior</i>	
Skin.	Internal jugular	Pleura.	Pleura.	
Superficial fascia.	lar	Recurrent laryngeal nerve.	Recurrent laryngeal and cardiac branches of vagus	Nerves.
Platysma.	Vertebral		Ansa subclavia with lower cardiac branches	
Cervical fascia.	Anterior jugular		Interior cervical ganglion.	
Sterno-mastoid	Vagus		Sympathetic trunk.	
Sterno-hyoid	Ansa subclavia and superior cervical cardiac branch		Longus cervicis muscle.	
Sterno-thyroid				
<i>Inferior and Anterior.</i>				
Subclavian Commencement of right and left innominate				

**RELATIONS OF 1ST PART OF LEFT
SUBCLAVIAN**

<i>Anterior.</i>		<i>Medial.</i>	<i>Posterior.</i>	
Skin.	Anterior jugular	Left carotid.	Longus cervicis.	
Superficial fascia.	lar	Trachea.	Thoracic duct (below).	
Platysma.	Left innominate	(Esophagus.	Interior cervical	
Manubrium sterni.	Internal jugular	Thoracic duct.	ganglion.	
Cervical fascia.	lar	Vagus.	Sympathetic trunk.	
Sterno-mastoid	Vertebral	Lower cervical cardiac branches of sympathetic.	Pleura.	
Sterno-hyoid	Left phrenic	Left recurrent laryngeal nerve.		
Sterno-thyroid	Left vagus			
Left common carotid artery.	Ansa subclavia			
	Thoracic duct (above)			
			<i>Lateral and Posterior.</i>	
			Left lung.	
			Pleura.	

RELATIONS OF 2ND PART OF SUBCLAVIAN

<i>Anterior.</i>		<i>Posterior</i>	<i>Inferior.</i>	
Skin.	Subclavian vein (below level).	Pleura and lung.	Pleura.	
Superficial fascia.	Phrenic nerve (on right side).			
Platysma.				
Cervical fascia.				
Sterno-mastoid (clavicular origin)			<i>Superior.</i>	
Scalenus anterior			Brachial plexus	

RELATIONS OF 3RD PART OF SUBCLAVIAN

Contained in subclavian triangle, and enclosed in sheath of cervical (prevertebral) fascia.

<i>Anterior.</i>		<i>Inferior.</i>
Skin.	Suprascapular artery.	1st rib.
Superficial fascia.	Clavicle.	
Descending cutaneous	Subclavius	<i>Posterior</i>
branches of cervical	Nerve to subclavius.	Scalenus medius.
plexus.		Lowest brachial
Platysma.	<i>Superior.</i>	plexus trunk.
Cervical fascia.	Brachial plexus.	
External jugular		
Subclavian		
Branch from cephalic		
to external jugular		
Suprascapular		
Transverse cervical		
Anterior jugular		

BRANCHES FROM 1ST PART

VERTEBRAL: From upper and back part. *First part:* Passes upwards and backwards, behind inferior thyroid artery and internal jugular and vertebral veins, then between scalenus anterior and longus cervicis, to enter foramen in transverse process of 6th cervical vertebra. *Second part:* Ascends in corresponding foramina as far as axis, having vertebral vein in front and cervical nerves behind. It then passes laterally and upwards, through foramen in atlas. *Third part:* Winds backwards and medially on vertebral groove of atlas, lying in the floor of the suboccipital triangle, having the trunk of the 1st cervical nerve beneath it, and the posterior ramus of same nerve crossing it behind. *Fourth part:* Pierces posterior atlanto-occipital membrane and dura mater, and enters skull through foramen magnum. It then winds round medulla, over top of ligamentum denticulatum, passing between hypoglossal and anterior root of 1st cervical nerve to front of medulla, uniting with fellow, to form the basilar artery (see p. 145), at the lower border of the pons. Carries sympathetic fibres from cell bodies in inferior cervical ganglion.

Cervical branches of vertebral artery

Spinal : Each enters vertebral canal through an intervertebral foramen, supplying posterior root ganglion and nerve roots.

Muscular : To deep cervical muscles

Cranial branches

Posterior meningeal : Arises before vertebral pierces dura mater opposite foramen magnum, to falx cerebelli and dura in posterior fossa.

Posterior spinal : Arises opposite posterior part of medulla, passes down back of cord behind posterior nerve roots. Supplies posterior grey and posterior white columns.

Anterior spinal : Given off near end of artery, descends in front of medulla, unites with opposite fellow just below foramen magnum to form a single artery, which is continued along the cord, anastomosing with the posterior artery over conus medullaris; supplies pia mater and lateral and anterior white columns and anterior grey column.

NOTE.—Reinforcement by spinal branches is negligible except at T. I and T. II levels (the *arteries of Adamkiewicz*) for cervical and lumbar enlargements of cord.

Posterior inferior cerebellar : Arising near pons, very tortuous course between roots of hypoglossal and then between accessory and vagus nerves, to reach under surface of cerebellum; *anas.* superior cerebellar. Supplies hemisphere, vermis, *choroid plexus of 4th ventricle* and posterior part of medulla.

Medullary arteries enter medulla.

THYRO-CERVICAL TRUNK : A short thick trunk from front of artery near medial border of scalenus anterior, quickly dividing into:

(a) **Inferior thyroid :** Passes upwards on vertebral artery and under internal jugular vein; then medially and downwards behind sheath of carotid and sympathetic (middle cervical ganglion); finally turns medially to lower part of thyroid gland. Carries sympathetic fibres from cell bodies in middle cervical ganglion.

Branches

Ascending cervical : Arises as inferior thyroid turns behind carotid sheath, ascends medial to phrenic nerve and between scalenus anterior and longus capitis supplying them.

Inferior laryngeal : Upwards on trachea to back of larynx, with recurrent laryngeal nerve.

Tracheal : To trachea; *anas.* bronchial.

Œsophageal : To cervical and superior mediastinal part of œsophagus

Glandular : Divides outside pretracheal fascia, 4 or 5 branches pierce it separately (*cf.* superior thyroid artery, p. 136) to lower pole of thyroid gland. Recurrent laryngeal nerve lies close behind them.

(b) **Suprascapular :** Runs downwards at first, over scalenus anterior and phrenic nerve, just above 3rd part of subclavian, then runs transversely outwards, behind and parallel to clavicle, to upper edge of scapula under cover of trapezius; inclining downwards with nerve to pass over suprascapular ligament on suprascapular notch, enters supraspinous fossa in contact with the bone beneath supraspinatus, which it supplies. It then winds over neck of scapula to infraspinous fossa; *anas.* with circumflex scapular arteries and deep branch of transverse cervical

Branches

Muscular : To neighbouring muscles, especially sterno-mastoid.

Acromial : Through trapezius to acromion; *anas.* acromio-thoracic.

Subscapular : Arises as suprascapular passes over notch; *anas.* in subscapular fossa with deep branch of transverse cervical and subscapular of axillary.

This anastomosis around the scapula is an important collateral circulation after ligation of the third part of the subclavian artery.

Infraspinous : Descends on neck of scapula to fossa; *anas.* circumflex scapular and deep branch of transverse cervical. (See note on p. 154)

Articular : To shoulder-joint. **Nutrient :** To clavicle and to scapula.

. (c) **Transverse cervical**: Over *scaleni* muscles, phrenic nerve, and brachial plexus, under omo-hyoid, to lateral edge of levator scapulae, there dividing into:—

Superficial branch: Ascends beneath anterior edge of trapezius, supplying it together with glands, skin and muscles of that region; *anas.* superficial descending branch of occipital artery.

Deep branch: Backwards to superior angle of scapula beneath levator scapulae, then downwards along medial border of scapula with nerve to rhomboids under the rhomboids supplying surrounding muscles; *anas.* suprascapular, subscapular. (See note on p. 154.)

Note. Either or both of suprascapular and transverse cervical arteries may arise from third part of subclavian and run between trunks of brachial plexus.

INTERNAL MAMMARY: From under surface of subclavian just below thyro-cervical trunk, runs down behind clavicle and subclavian vein to posterior surface of 1st costal cartilage, being crossed here by phrenic nerve; downwards between pleura and costal cartilages, crossed by intercostal nerves and lying on transversus thoracis (*sterno-costalis*) (*i.e.* in neuro-vascular plane) as far as the 6th space, there dividing into two terminal branches.

Branches

Pericardiaco-phrenic: Arises high in chest, accompanies phrenic nerve between pleura and pericardium to diaphragm, supplying it; *anas.* musculo-phrenic, phrenic of abdominal aorta.

Anterior mediastinal: To areolar tissue and glands of anterior mediastinum and thymus gland.

Anterior intercostal: To upper five or six intercostal spaces, two in each space; *anas.* with aortic intercostals.

Note this important anastomosis between branches from the subclavian (proximal to site of "coarctation" of aorta) and the aortic intercostals.

Perforating: Perforate upper five or six intercostal spaces to supply pectoral muscles and mammary

gland; branches to breast especially large in second and third spaces.

Myosculo-phrenic : Lateral of two terminal branches perforates diaphragm about 9th intercostal space, supplying diaphragm, and branches to lower intercostal spaces.

Superior epigastric : Medial terminal branch passes behind 7th costal cartilage and pierces diaphragm; lies posterior to rectus within the sheath, terminating in that muscle; *anas.* inferior epigastric of external iliac.

BRANCH FROM 2ND PART OF SUBCLAVIAN.

COSTO-CERVICAL TRUNK : From upper and back part behind scalenus anterior, bends backwards over pleural dome in front of neck of 1st rib, where the 1st intercostal nerve is lateral, and 1st thoracic ganglion of sympathetic medial to artery. It divides into:

Supreme (superior) intercostal : Which supplies 1st and 2nd intercostal spaces, small branches to cord and deep muscles of back.

Deep cervical : Corresponds to posterior branch of an aortic intercostal; passes between transverse process of 7th cervical vertebra and 1st rib, ascending beneath semispinalis capitis to axis; *anas.* vertebral and deep descending branch of occipital.

THE ARTERIES OF THE UPPER LIMB

THE AXILLARY ARTERY

Extent.—From lateral border of 1st rib to lower border of teres major. Divided into three parts separated by pectoralis minor:

1ST PART—**Extent**: From lateral border of 1st rib to upper border of pectoralis minor.

Relations—**Anterior**: Pectoralis major, clavipectoral fascia, cephalic vein, lateral pectoral nerve, and branches of acromio-thoracic artery.

Posterior : 1st intercostal space and muscle, 1st serration of serratus anterior, nerve to serratus anterior.

Medial : Medial pectoral nerve and axillary vein.

Lateral : Brachial plexus.

2ND PART—*Extent* : From superior to inferior border of pectoralis minor.

Relations—*Anterior* : Pectorales minor and major.

Posterior : Subscapularis, posterior cord of plexus.

Medial : Medial cord of plexus, separating artery from vein.

Lateral : Lateral cord of plexus.

3RD PART—*Extent* : From inferior border of pectoralis minor to lower border of teres major.

Relations—*Anterior* : Pectoralis major, medial head of median and medial cutaneous nerve of forearm; below, skin and fasciæ.

Posterior : Subscapularis, tendons of latissimus dorsi and teres major, radial and circumflex nerves.

Medial : Ulnar nerve, axillary vein, and medial cutaneous nerve of arm.

Lateral : Coraco-brachialis, median and musculocutaneous nerves.

Branches

Superior thoracic (1st part): Arises opposite 1st intercostal space, supplies pectorales; *anas.* internal mammary, intercostals.

Acromio-thoracic (1st part): Arises from front of artery at upper border of pectoralis minor.

Branches :

Acromial : Supply and perforate deltoid; *anas.* branch of suprascapular and posterior circumflex humeral.

Deltoid : Accompanies cephalic vein; *anas.* anterior circumflex humeral.

Pectoral : Two or three branches to supply side of thorax; *anas.* intercostal.

Clavicular : One or two twigs to clavicle and subclavius.

Lateral thoracic (2nd part): Passes downwards along inferior border of pectoralis minor to about 6th intercostal space; supplies pectorales and serratus anterior; *anas.* intercostal and other thoracic branches.

In female gives branches to mammary gland *lateral mammary*.

Subscapular (3rd part): Arises opposite lower border of subscapularis muscle, and courses with the nerve to latissimus dorsi to lower angle of scapula.

Branch

Circumflex scapular: Given off near origin to dorsum of scapula, passes backwards to the infraspinous fossa through triangular space (p. 73). In the triangular interval it gives off ventral branches to subscapular fossa, and a *descending* branch which runs down between the two teres muscles to the angle. Supplies subscapularis, latissimus dorsi, teres major, serratus anterior; *anas.* suprascapular and deep branch of transverse cervical.

Note the very important anastomoses in the scapular region between branches of the 1st part of the subclavian (p. 150) and the 3rd part of the axillary.

Posterior circumflex humeral (3rd part): Arises from back of artery opposite lower border of subscapularis, winds backwards through quadrilateral space (p. 73). Supplies deltoid, head of humerus, shoulder-joint, teres minor, and long head of triceps; *anas.* acromio-thoracic, anterior circumflex humeral and profunda brachii.

Anterior circumflex humeral (3rd part): Arises from lateral side of artery; one branch ascends in bicipital groove to shoulder-joint (*i.e.* long head of biceps), another winds round surgical neck of humerus. *anas.* posterior circumflex humeral

THE BRACHIAL ARTERY

Extent: From lower border of teres major to $\frac{1}{2}$ inch below bend of elbow; runs along medial borders of coraco-brachialis and biceps, accompanied by venæ comitantes. Note that upper half of artery is on medial side of arm and lower half on front of arm.

Relations—Anterior: Skin, fascia, upper part of coraco-brachialis, biceps and bicipital aponeurosis,

median basilic vein. Crossed by medial nerve from lateral to medial at insertion of coraco-brachialis.

Posterior : Long and medial heads of triceps, lower part of coraco-brachialis, brachialis, radial nerve, profunda brachii vessels.

Medial : Medial cutaneous nerve of forearm to about middle of arm, ulnar nerve to insertion of coraco-brachialis, median nerve from insertion of coraco-brachialis to elbow.

Lateral : Coraco-brachialis and biceps. Median nerve from origin of artery to insertion of coraco-brachialis.

Branches

Profunda brachii : Arises opposite lower border of teres major, winds backwards and laterally with radial nerve in the spiral groove; gives off anterior branch which pierces lateral intermuscular septum (*anas.* radial recurrent); and ends as posterior branch behind lateral epicondyle; *anas.* posterior circumflex humeral, interosseous recurrent and supratrochlear. Supplies triceps, anconeus.

Nutrient : Arises about middle of humerus, and enters nutrient foramen just below insertion of coraco-brachialis.

Ulnar collateral (superior) : Arises opposite insertion of coracobrachialis, accompanies ulnar nerve, pierces medial intermuscular septum, *anas.* posterior ulnar recurrent and supratrochlear at elbow.

Ulnar collateral inferior (supratrochlear) : Arises 2 inches above elbow-joint, courses to hollow between olecranon and medial epicondyle of humerus, *anas.* ulnar collateral superior, anterior and posterior ulnar recurrent, and a branch across the back of olecranon fossa from profunda brachii. Supplies elbow-joint.

Muscular : To coraco-brachialis, biceps, brachialis

THE RADIAL ARTERY

Extent : From bifurcation of the brachial to the deep palmar arch of hand; accompanied by venæ comitantes.

Relations in the forearm—Anterior : Skin, fascia, brachio-radialis.

Posterior : Tendon of biceps, supinator, pronator teres, radial head of flexor digitorum sublimis, flexor pollicis longus, pronator quadratus, lower end of radius.

Medial : Pronator teres, flexor carpi radialis.

Lateral : Brachio-radialis tendon, and for middle $\frac{1}{2}$ radial nerve.

The artery courses along medial border of brachio-radialis tendon to carpus, winds round carpus beneath extensors of thumb and radial nerve, lying on lateral ligament of wrist, scaphoid and trapezium, enters palm of hand between the heads of the 1st dorsal interosseous muscle and adductor pollicis, forming deep palmar arch. (Fig. 31, p. 83).

Branches

Radial recurrent : Arises just below elbow, ascends between brachialis and brachio-radialis, supplying them and the elbow-joint; *anas.* profunda brachii

Muscular : To muscles of radial side of forearm.

Superficial palmar : Arises when the artery is about to wind round carpus, passes between muscles of ball of thumb; *anas.* with ulnar, completing superficial palmar arch.

Anterior carpal : Arises near lower border of pronator quadratus, passes medially under tendons; *anas.* anterior carpal of ulnar.

Posterior (dorsal) carpal : Arises beneath extensor tendons of thumb; *anas.* posterior carpal of ulnar, forming *dorsal carpal arch*, which gives off 2nd, 3rd and 4th *dorsal metacarpal* to 2nd, 3rd and 4th spaces; each *anas.* with superior perforating of deep arch, and at distal end of interosseous space gives off inferior perforating to join palmar digital arteries.

1st dorsal metacarpal (1st dorsal interosseous) : Arises near or with the posterior radial carpal; *anas.* superior perforating of deep arch, digital of superficial arch; supplies adjoining sides of thumb and index finger.

Dorsalis pollicis : Arising near base of 1st metacarpal, runs along sides of dorsum of thumb.

Princeps pollicis : Arising as the artery enters palm, courses between 1st metacarpal and oblique head of adductor pollicis to the base of proximal phalanx, where it divides into two terminal branches, which run along the sides of the palmar surface of thumb.

Radialis indicis : Arising near the preceding, passes between 1st dorsal interosseous and transverse head of adductor pollicis to lateral side of index finger, sends a branch to superficial palmar arch; *anas.* digital of superficial arch.

Deep palmar arch : *Extent*, from upper end of 1st interosseous space to base of 5th metacarpal. It lies over the bases of the metacarpal bones, and terminates by anastomosing with the deep branch of the ulnar.

Branches

Recurrent : To front of carpus; *anas.* carpal arteries.

Palmar metacarpal (3) : In the three medial interosseous spaces join digital of superficial arch at cleft of fingers, and an offset from medial branch joins digital branch to medial side of 5th finger.

Superior perforating : Pierce three medial dorsal interossei; *anas.* dorsal interosseous.

THE ULNAR ARTERY

Extent : From bifurcation of brachial to superficial palmar arch, coursing along lateral side of flexor carpi ulnaris to the palm; accompanied by venæ comitantes.

Relations in the forearm—Anterior : Pronator teres (both heads), flexor carpi radialis, palmaris longus, flexor sublimis, median nerve in upper half; lower half, overlapped by flexor carpi ulnaris tendon.

Posterior : Brachialis, flexor digitorum profundus.

Medial : Flexor carpi ulnaris, the ulnar nerve in the lower $\frac{2}{3}$.

Lateral : Flexor digitorum superficialis (sublimis).

Lies upon flexor retinaculum at wrist, lateral to the ulnar nerve and pisiform bone.

Branches

Anterior ulnar recurrent: Arises near beginning of ulnar, ascends between brachialis and pronator teres, supplying them; *anas.* ulnar collateral, supratrochlear.

Posterior ulnar recurrent: Arising below the anterior, passes beneath flexor sublimis, ascends behind medial epicondyle, thence between heads of flexor carpi ulnaris, supplying elbow-joint and muscles around; *anas.* ulnar collateral, supratrochlear.

Common interosseous: About $\frac{1}{2}$ inch long, arising just below radial tuberosity, passes to interosseous membrane, there dividing into two terminal branches.

Branches

Anterior interosseous: Passes down forearm, resting upon anterior surface of interosseous membrane, accompanied by and medial to anterior interosseous branch of median nerve. At upper border of pronator quadratus one branch goes downwards beneath quadratus to *anas.* with anterior carpal and deep arch; the other, piercing interosseous membrane, descends to back of carpus; *anas.* posterior interosseous, posterior carpal of radial and ulnar. Supplies *nutrient* branches to radius and ulna, *muscular branches*, and *median* branch to median nerve.

Posterior interosseous: Passes backwards between oblique cord and interosseous membrane, and between supinator and abductor pollicis longus, runs down back of forearm, lying medial to posterior interosseous nerve, between superficial and deep muscular layers as far as the perforating branch of anterior interosseous, *anas.* posterior carpal of radial and ulnar, anterior interosseous

Branch - Interosseous recurrent: Given off near origin, passes under anconeus to interval between olecranon and lateral epicondyle; *anas.* profunda brachii, supratrochlear.

Muscular: To muscles on ulnar side of forearm.

Anterior ulnar carpal: Courses beneath tendons of flexor profundus; *anas.* anterior carpal of radial.

Posterior carpal: Arises just above pisiform, winds back beneath flexor carpi ulnaris tendon, gives

branch to medial side of 5th metacarpal, and then passes laterally to *anas*, with posterior carpal of radial, forming *dorsal carpal arch* (see p. 156).

Superficial palmar arch : Continues the ulnar in the hand, lying immediately under palmar aponeurosis and on digital nerves and flexor tendons. It turns laterally a little below the flexor retinaculum, and, forming an arch with the convexity downwards, is directed to the thumb, where the arch becomes completed by joining the superficial palmar of radial, *radialis indicis*, or *princeps pollicis*. From the convex side of the arch it gives off four *palmar digital* branches to supply three medial fingers and medial side of index finger; *anas*, palmar metacarpal of deep arch, inferior perforating of dorsal interosseous.

The **deep branch of ulnar artery** or communicating branch is given off at commencement of arch, passes down with the deep branch of ulnar nerve between abductor and short flexor of little finger to complete deep palmar arch (p. 157).

ABDOMINAL AORTA

Extent : From last thoracic vertebra to the left side of front of body of 4th lumbar vertebra, there dividing into common iliacs.

Course : Enters abdomen between crura of diaphragm, occupying middle line of spine, but near its bifurcation inclines to left side.

Relations—Anterior, from above down : Lesser omentum, stomach, celiac plexus, pancreas, splenic vein, left renal vein, 3rd part of duodenum, root of mesentery, coils of small intestine, aortic plexus and peritoneum. It touches the pancreas and duodenum without any intervening peritoneum.

Posterior : Bodies of upper 4 lumbar vertebrae, left lumbar veins, cisterna chyli and thoracic duct.

On right side . Inferior vena cava, thoracic duct, vena azygos, and right celiac ganglion. Right trunk of sympathetic.

On left side : Left celiac ganglion, and left trunk of sympathetic.

Branches

Phrenic (2): Arising close together immediately below diaphragm, pass on its under surface across crura, the left one passing behind œsophagus, the right one behind inferior vena cava.

Branches

Medial: To fore-part of diaphragm; *anas.* fellow, and pericardiaco-phrenic and musculo-phrenic of internal mammary.

Lateral: To lateral side of diaphragm; *anas.* musculo-phrenic, lower intercostals.

Superior suprarenal: To suprarenal gland

Cœliac artery: Arises between crura of diaphragm, just above pancreas, $\frac{1}{2}$ inch long, surrounded by cœliac plexus, divides into three visceral branches for supply of foregut.

Branches

LEFT GASTRIC. Smallest of three branches, directed upwards and to left behind lesser sac of peritoneum to cardiac end of stomach; gives off a few *œsophageal* branches, then turns to right along lesser curvature, giving branches to each surface of viscus; finally anastomoses with right gastric of hepatic.

HEPATIC: Directed to right, forwards and upwards between layers of lesser omentum, and anterior to opening into lesser sac, to porta hepatis, lying to left of bile-duct and in front of portal vein; at porta hepatis it divides into *right* and *left* hepatic, supplying corresponding lobes of the liver.

Branches

Right gastric: Runs along lesser curvature of stomach from right to left; *anas.* left gastric.

Gastro-duodenal: Passes behind 1st part of duodenum, divides at lower border into the two following branches:

Right gastro-epiploic: Runs along greater curvature of stomach from right to left; *anas.* with left gastro-epiploic of splenic, gives off branches upwards to viscus and downwards to greater omentum.

Superior pancreatico-duodenal : Runs between the 2nd part of duodenum and the pancreas down to *anas.* with inferior pancreatico-duodenal of superior mesenteric.

Right hepatic : To right lobe of liver, giving off *Cystic :* To supply gall-bladder.

Left hepatic : To left lobe, giving off branch to caudate lobe.

SPLENIC : Directed horizontally on tortuous course to left along upper border of pancreas, crossing the left kidney, reaches spleen by passing between two layers of lienorenal ligament, and then gives off gastric branches which reach stomach between layers of gastro-splenic ligament; supplies spleen and partly stomach and pancreas. *Very tortuous;* divides near spleen into several terminal branches which enter hilum of that viscus.

Branches

Pancreatic : Given off as artery runs along pancreas; one of them (*arteria pancreatica magna*) accompanies the duct, running from right to left.

Left gastro-epiploic : Directed to right side between layers of greater omentum, along greater curvature of stomach; *anas.* with right gastro-epiploic of hepatic.

Short gastric branches (5 or 6). Extend to left extremity of stomach to supply its coats.

Middle suprarenal (2): Arises a little below celiac artery; runs transversely outwards over crus of diaphragm to suprarenal gland; *anas.* superior suprarenal of phrenic and inferior suprarenal of renal.

Superior mesenteric: Artery of midgut (from duodenal papilla to just short of left colic flexure). Arises $\frac{1}{4}$ inch below celiac artery, passes downwards between pancreas and upper border of 3rd part of duodenum, crosses duodenum, and, directed downwards and to the right between the layers of the mesentery, terminates in offsets to small intestine, cæcum and colon.

Relations—Anterior and superior : Pancreas and splenic vein. **Posterior:** Uncinate process of pancreas, duodenum (3rd part) and left renal vein. Surrounded

by mesenteric plexus of nerves and accompanied by its vein, which lies to right.

Branches

Inferior pancreatico-duodenal : Directed from left to right along concave border of 3rd part of duodenum; *anas.* superior pancreatico-duodenal.

'Middle colic : Passing forward in transverse meso-colon from upper part of right side of artery, supplies transverse colon; *right* branch *anas.* right colic; *left* branch *anas.* proximal to splenic flexure, with upper left colic of inferior mesenteric.

Jejunal and ileal branches : To supply jejunum and ileum, twelve or fifteen in number; spring from left convex side of artery; about 2 inches from origin they bifurcate, each division uniting with a neighbouring branch to form an arcade, from which branches issue; these divide and communicate in the same way four or five times, the resultant branches proceeding directly to intestine (more arcades distally, to supply ileum).

Right colic (often a branch of ileo-colic) : From right side of trunk to middle of ascending colon, *ascending* branch *anas.* middle colic, *descending* branch *anas.* ileo-colic.

Ileo-colic : From right side of artery down to cæcum and appendix. Divides into *anterior* and *posterior* cæcal, from latter comes *appendicular* branch. A *descending* branch to lower part of ileum. An *ascending* to ascending colon and *anas.* with right colic.

Renal (2) : One from each side arising $\frac{1}{2}$ inch below superior mesenteric, the right a little lower than the left one. Pass laterally to supply kidneys, the right one passing behind inferior vena cava. Each divides near viscus into three branches, which enter hilum two in front and one behind ureter, the last high up (branch entering hilum behind ureter low down may cause hydronephrosis). Renal vein lies anterior. Is accompanied by plexus of nerves; supplies branches to suprarenal gland (*inferior suprarenal*), ureter and fatty capsule.

Testicular : Two small but very long arteries; each

arises just below renal, directed downwards and laterally behind peritoneum over psoas, crossing ureter to which it gives branches and external iliac artery (the right one crosses also the inferior vena cava) to deep inguinal ring; thence accompanied by spermatic vein, pampiniform plexus, and vas deferens, it passes along inguinal canal, and out of the superficial ring to the scrotum, where it divides into branches which enter the posterior surface of the testis; *anas.* (often very poor) artery of vas deferens and cremasteric.

In the female the artery is termed **ovarian**, and runs between layers of broad ligament of uterus, to ovary and tube; *anas.* uterine.

Inferior mesenteric: Artery of hindgut, from splenic flexure to mucous membrane at ano-cutaneous junction. Arises on left side of aorta, about $1\frac{1}{2}$ inches above bifurcation. Lies at first on left side of aorta, then crosses over left psoas, left common iliac vessels and ureter, to back of rectum, supplies left half of transverse colon, descending and pelvic parts of colon, rectum and anal canal.

Branches

Superior left colic: Directed upwards in front of left kidney, *ascending* branch *anas.* middle colic; *descending* branch supplies descending colon; *anas.* inferior left colic.

Inferior left colic: To descending and pelvic colon; *anas.* superior left colic and superior rectal.

Superior rectal: Continuation of inferior mesenteric trunk, passes into pelvis between layers of pelvic meso-colon (giving branches to lower part of pelvic colon) and divides into two branches, which pass down, behind rectum, to about 6 inches from anus, where they subdivide to supply rectum and anal canal; *anas.* inferiorly with middle and inferior rectals. At upper limit of its distribution there may be a gap in arterial anastomotic loops, which is of some surgical importance.

Marginal artery: Anastomoses between ileo-colic, right, middle and left colics result in a continuous arterial line at margin of gut from cæcum to rectum,

reinforced by above-named arteries. Occasionally deficient in places, the marginal artery is usually continuous.

Lumbar (4 pairs): Arise from *back* of aorta, pass laterally, resting on body of corresponding vertebra underneath sympathetic trunk and psoas; the two upper pairs under crura of diaphragm; the right ones also under vena cava. Divide near transverse processes into:

Abdominal: Coursing laterally behind quadratus (the last pair cross quadratus), to end between muscles of abdominal wall in neuro-vascular plane, *anas.* inferior epigastric, intercostals, ilio-lumbar, deep circumflex iliac.

Posterior: Accompanies posterior primary ramus of nerve; gives off *spinal* branch to supply meninges and spinal nerve roots; *anas.* intercostal.

Median sacral: A small branch given off just at bifurcation of aorta courses over 5th lumbar vertebra and middle of sacrum to coccyx behind the left common iliac vein. It is, both morphologically and embryologically, continuation of abdominal aorta to the tail; *anas.* lateral sacral.

THE COMMON ILIAC ARTERY

Extent: From bifurcation of aorta, on body of 4th lumbar vertebra, to opposite brim of pelvis at sacro-iliac joint, level with lumbo-sacral articulation, there dividing into external and internal iliac. About 2 inches long.

Relations—Anterior: Peritoneum, small intestine, ureter, branches of sympathetic.

Differences between right and left artery: The *right* one is the longer, the aorta being on the left side of spine; on right side are inferior vena cava and right psoas. Companion vein at first behind, but to the right at upper part; left common iliac vein crosses behind right artery. The *left* one is crossed anteriorly by inferior mesenteric artery, the companion vein is below and medial.

THE INTERNAL ILIAC ARTERY

Extent : From bifurcation of common iliac opposite lumbo-sacral articulation to greater sciatic notch, there dividing into *anterior* and *posterior* trunks; $1\frac{1}{2}$ inches long.

Relations—*Anterior*: Peritoneum; ureter runs downwards in front of the artery, ileum on right, pelvic colon on left. *Posterior*: Medial border of psoas, internal iliac vein, lumbo-sacral trunk and sacrum. Note that this artery lies inside parietal layer of pelvic fascia, which is pierced by all the parietal branches—*e.g.* gluteal arteries.

From the extremity a fibrous cord, the *lateral umbilical ligament*, formed from an obliterated artery, the umbilical, extends forwards to side of bladder, under parietal peritoneum. In the *fœtus* this vessel is nearly as large as the common iliac, ascends the wall of abdomen to umbilicus, passing thence as umbilical artery to placenta, after birth the vessel becomes obliterated except $1\frac{1}{2}$ inches at commencement.

Branches from anterior trunk

Superior vesical : Is the unobliterated part of umbilical, extending from greater sciatic notch to side of bladder.

Branches supplied to side and upper part of bladder, and to ureter. *Artery of vas deferens*: Accompanies vas to *anas.* with testicular. May arise from inferior vesical.

Inferior vesical : Supplies base of bladder, side of prostate and seminal vesicles in the male.

Middle rectal : Badly named. Supplies *prostate* and *muscularis* of rectum and, in the female, *vagina*. May come off from inferior vesical; *anas.* superior rectal of inferior mesenteric, inferior rectal of internal pudendal (very poor anastomosis).

[Uterine : Down to neck of uterus, passes medially between layers of broad ligament, where it crosses the ureter superiorly, and then divides into a large ascending branch to uterus and ovary, *anas.* ovarian, and small descending branch to vagina, *anas.* vaginal.

Vaginal : Corresponds to inferior vesical in male;

supplies vagina, base of bladder, and lower part of rectum.]

Obturator : Directed to groove in upper part of obturator foramen, passing out of pelvis and dividing into two branches at upper border of obturator externus. In pelvis it is placed between pelvic fascia and peritoneum, and just below obturator nerve. It lies beneath the superior ramus of pubis with companion vein and nerve in canal formed above by bone and below by obturator membrane.

Branches within pelvis

Iliac : Enters iliac fossa, supplies iliacus and bone; *anas.* ilio-lumbar.

Pubic : Ascends posterior surface of pubis; *anas.* opposite fellow, inferior epigastric. (See p. 169.)

Branches outside pelvis

Medial terminal : Curves medially beneath obturator externus; supplies obturators, gracilis, and adductors; *anas.* medial circumflex, and lateral branch of obturator.

Lateral terminal : Passes downwards and laterally beneath obturator externus to ischial tuberosity; supplies obturator, hamstrings, and hip-joint; *anas.* inferior gluteal and medial branch of obturator

Internal pudendal :

In the male : Proceeds out of pelvis by greater sciatic foramen below piriformis, winds round ischial spine, re-enters pelvis by lesser foramen, passes in pudendal canal on medial side of tuberosity of ischium, courses along ischial ramus, perforates the perineal membrane very obliquely, dividing into dorsal and deep arteries of penis.

Relations : In the pelvis, lies lateral to rectum in front of piriformis and sacral plexus. In gluteal region is seen under gluteus maximus, on ischial spine, below piriformis, lateral to pudendal nerve, and medial to nerve to obturator internus. Thence, with nerve above and vein below, it lies in pudendal canal on lateral wall of ischio-rectal fossa, and medial to obturator internus.

Branches

Inferior rectal : Arises just medial to ischial tuberosity, piercing medial wall of pudendal canal, crosses roof of ischio-rectal fossa obliquely, supplies sphincter and levator ani, *anas.* superior rectal (very poor) and opposite fellow.

Scrotal : Arising half-way in ischio-rectal fossa, runs parallel to pubic arch, crossing superficial transversus perinei, lying deep to deep layer of superficial fascia, between ischio-cavernosus and bulbo-spongiosus, supplying them together with scrotum; *anas.* external pudendal of femoral.

Transverse perineal : Arises from scrotal or from trunk near it, courses transversely inwards, supplying skin, etc.

Artery of bulb : Arises near base of perineal membrane, as internal pudendal artery lies between the perineal membrane and levator ani; it then pierces former, reaching bulb $\frac{1}{2}$ inch from base. Supplies a branch to bulbo-urethral gland.

Deep artery of penis : Pierces perineal membrane to enter crus and is distributed to corpus cavernosum.

Dorsal artery of penis : Lies between crus and pubic ramus, passes through suspensory ligament, along dorsum of penis, having the deep dorsal vein medial and the dorsal nerve lateral. It ends in the glans and prepuce.

In the female : The vessel is smaller, and has similar course to that in male; the *labial* supplies labium pudendi. The *artery of bulb* supplies bulb of vestibule. The terminal arteries supply clitoris, as *dorsal* and *deep arteries of clitoris* respectively.

Inferior gluteal : Terminal branch of anterior trunk (see p. 169).

Branches from posterior trunk

Superior Gluteal : (See p. 170).

Ilio-lumbar : Passes upwards, backwards, and laterally beneath psoas and obturator nerve, but anterior to lumbo-sacral trunk; *ascending* or *lumbar* branch supplying psoas, quadratus lumborum, and giving a

spinal branch through foramen between 5th lumbar vertebra and the sacrum; *transverse* or *iliac* ramifies in iliacus, gives *nutrient branch* to ilium; *anas. lumbar*, deep circumflex iliac.

Lateral sacral (2): *Superior*, the larger of the two, distributed to upper part of sacrum; the *inferior* to lower part of sacrum and coccyx; *anas. median sacral* and opposite artery.

Branches (dorsal) are given off, which enter anterior sacral foramina for distribution on back of sacrum to muscles and skin.

THE EXTERNAL ILIAC ARTERY

Extent: From bifurcation of common iliac opposite sacro-iliac joint to lower border of inguinal ligament.

Surface-marking: Lower $\frac{2}{3}$ of line from $\frac{1}{4}$ inch below and little to left of umbilicus, to point on inguinal ligament midway between symphysis pubis and anterior superior iliac spine.

Relations: Covered by peritoneum and subperitoneal fat; crossed by ureter, vas deferens and deep circumflex iliac vein, left by pelvic colon. The testicular vessels and genito-femoral nerve lie on it for a short distance.

Lateral: Psoas, except at termination, where it is behind. **Medial:** Its own vein and lymphatic glands.

Branches

Inferior epigastric: From front of artery, just above inguinal ligament; passes upwards and medially between peritoneum and fascia transversalis, being crossed laterally by vas deferens near deep inguinal ring; pierces transversalis fascia, and then passes upwards behind rectus to enter sheath under arcuate line; terminates by anastomosing with superior epigastric branch of internal mammary.

Branches

Artery to cremaster: Accompanies vas deferens, supplying cremaster; *anas. testicular*, artery of vas deferens.

Pubic : Ramifies behind pubis; *anas.* pubic of obturator. This artery is frequently enlarged to replace the obturator artery—constituting the **abnormal obturator artery**.

Muscular : To rectus; *anas.* superficial epigastric.

Deep circumflex iliac : From lateral side of artery, near inguinal ligament, directed to anterior superior iliac spine, then on iliac crest, gradually piercing transversalis fascia and muscle and supplying lower part of abdominal wall; *anas.* ilio-lumbar, sup. glut., ascend. of lat. circumflex.

THE ARTERIES OF THE LOWER LIMB

THE INFERIOR GLUTEAL ARTERY

Branch of anterior division of internal iliac; passes out between roots of S. 1 and S. 2, through lower part of greater sciatic foramen, between piriformis and superior gemellus, in company with sciatic nerve and internal pudendal artery; outside the pelvis it lies between the ischial tuberosity and greater trochanter, under gluteus maximus, below which it ends in cutaneous branches to thigh.

Branches

Within the pelvis : *Muscular* to piriformis, coccygeus and levator ani.

Outside pelvis :

Coccygeal branch : Pierces sacro-tuberous ligament, inclines medially, supplies gluteus maximus, integument, etc.

Companion artery of sciatic nerve : Accompanies sciatic nerve; finally enters the substance of it.

Muscular : Branches to gluteus maximus and lateral rotators of thigh; *anas.* superior gluteal, medial circumflex.

Anastomotic : (1) To trochanteric fossa (*trochanteric anastomosis*), supplies lateral rotators; *anas.* superior gluteal, ascending of medial circumflex; and (2) to *cruciate anastomosis*; *anas.* first perforating, medial and lateral circumflex.

Articular : To capsule of hip-joint.

THE SUPERIOR GLUTEAL ARTERY

Largest branch of internal iliac, passes laterally between lumbo-sacral trunk and 1st sacral nerve, escapes from pelvis above piriformis, divides immediately into superficial and deep branches.

Superficial branch : Runs between the larger glutei, supplying gluteus maximus; *anas.* inferior gluteal and medial circumflex.

Deep branch : Goes between two smaller glutei, subdivides into two:

Superior division : Goes to anterior superior iliac spine; *anas.* circumflex iliacs, ascending branches of lateral circumflex; iliac of ilio-lumbar.

Inferior division : Supplies gluteal muscles, and descends to greater trochanter; *anas.* lateral circumflex.

Nutrient branch : Enters ilium just as artery emerges from pelvis.

THE FEMORAL ARTERY

Extent : From inguinal ligament to the opening in the adductor magnus, where it becomes popliteal artery.

Course : Thigh being abducted and rotated laterally, a line drawn from point midway between symphysis pubis and anterior superior iliac spine to adductor tubercle on medial condyle of femur will in upper $\frac{2}{3}$ give course.

Relations : Superficial in upper $\frac{1}{3}$ of thigh, being contained in femoral triangle, more deeply placed in middle $\frac{1}{3}$ (adductor canal). In first $1\frac{1}{2}$ inches is enclosed in femoral sheath.

Anterior : Skin, superficial and deep fascia, femoral branch of genito-femoral nerve, sartorius, saphenous nerve, aponeurotic arch over subsartorial canal.

Posterior : Psoas, profunda vessels, pectineus, adductor longus, femoral vein (at lower part of femoral triangle, and in subsartorial canal), tendon of adductor magnus.

Medial : Femoral vein (in femoral triangle), adductor longus.

Lateral : Femoral nerve. Sartorius (in femoral

triangle), vastus medialis, femoral vein gets to lateral side near ending.

Branches

Superficial epigastric : Arises $\frac{1}{2}$ inch below inguinal ligament, ascends through the saphenous opening to abdominal wall, as high as umbilicus, in the fascia; *anas.* fellow of opposite side, superficial branches of inferior epigastric.

Superficial circumflex iliac : Arises near preceding, runs laterally to iliac crest, supplies glands, fasciæ, and skin; *anas.* deep circumflex iliac, superior gluteal, lateral circumflex.

Superficial external pudendal : Arises from medial side of artery $\frac{1}{2}$ inch below inguinal ligament, pierces cribriform fascia of saphenous opening, runs upwards to pubic tubercle, crosses spermatic cord, supplying skin of lower part of abdomen and external genitals; *anas.* internal pudendal.

Deep external pudendal : Arises either separately or from a common trunk with the preceding, lies on pectineus, covered by fascia lata, which it pierces, passes behind spermatic cord and is distributed to scrotum in male (and labium in female), *anas.* scrotal or labial of internal pudendal.

Profunda femoris : Arises from lateral and back part of artery, 1 or 2 inches below inguinal ligament, and passes downwards in femoral triangle upon the iliacus, psoas, pectineus, adductor brevis and adductor magnus; the adductor longus passes superficial to it. It is separated from the femoral artery by the femoral and profunda veins and adductor longus. It ends in the lower third of thigh by perforating adductor magnus.

Branches

Lateral circumflex : Arises from the lateral side of the profunda (sometimes from the femoral trunk), coursing under rectus and sartorius laterally through the divisions of the femoral nerve, dividing into—

(a) *Transverse* branches, piercing vastus lateralis just below greater trochanter; *anas.* below trochanter with medial circumflex, first perforating branch of

profunda, and inferior gluteal (*cruciate anastomosis*).

(b) *Ascending*, pass beneath sartorius, rectus, and tensor fasciæ latæ; *anas.* with terminal of superior gluteal and deep circumflex iliac.

(c) *Descending* branch accompanies the nerve to the vastus lateralis; *anas.* with superior genicular arteries, a small offset passing, with the articular branch from the nerve to vastus lateralis, to the knee-joint.

Medial circumflex : Arises from the medial and back part of profunda, courses backwards between psoas and pectineus, and then below capsule of hip between obturator externus and adductor brevis, giving off muscular branches; divides at the lesser trochanter into two branches: one (*ascending*) passes upwards along upper border of quadratus femoris to the trochanteric fossa of the greater trochanter; *anas.* superior and inferior gluteal; the other (*transverse*) passes to the hamstrings, appears between adjacent borders of quadratus femoris and adductor magnus; *anas.* first perforating, inferior gluteal, and lateral circumflex (*cruciate anastomosis*). An *articular* branch enters the joint through the acetabular notch.

Perforating branches : Four in number, reach the back of thigh by perforating the adductor magnus, and end in vastus lateralis:

First, begins opposite lower border of pectineus, perforates adductor magnus above adductor brevis, distributed to biceps and gluteus maximus; *anas.* inferior gluteal, medial and lateral circumflex.

Second, comes off opposite middle of short adductor, perforating it and the magnus, distributed to hamstrings; a *nutrient* artery to femur (passing upwards) is given off; *anas.* other perforating branches.

Third, arises at the lower border of adductor brevis, perforates magnus, as the second, ending in the biceps.

Fourth, is the name applied to the terminal part of the profunda, which pierces adductor magnus near opening for femoral vessels, supplies short head of biceps; *anas.* popliteal and lower perforating.

Muscular branches : Two to seven in number, supplying sartorius and vastus medialis.

Descending genicular : Arises in the subsartorial canal. Divides into two branches:

Superficial (saphenous artery) accompanies saphenous nerve, leaving canal between gracilis and sartorius; *deep (articular branch)* enters vastus medialis and joins anastomosis around knee-joint.

THE POPLITEAL ARTERY

Extent : From the opening in the adductor magnus to lower border of popliteus, where it divides into anterior and posterior tibial. 8 inches long.

Course : Upper part inclines from medial side of femur to middle of intercondylar notch, thence occupying middle line of popliteal space.

Relations : The upper part of artery in the popliteal space is overlapped by the semimembranosus, and below it is covered by the gastrocnemius and plantaris. It rests upon the femur, oblique popliteal ligament of knee-joint and popliteus. The vein lies to the lateral side in the upper part, but crosses to the medial side near the termination. Superficial and slightly lateral to both vessels is the medial popliteal nerve in the upper part, but below it crosses to medial side. A small branch of the obturator nerve to the knee-joint courses upon the artery.

Branches

Muscular—Superior set (3 or 4): To hamstrings; *anas.* perforating of profunda, superior genicular.

Inferior set or sural (2): Arise from the posterior part of artery opposite knee-joint; supply both heads of gastrocnemius, plantaris and soleus.

Superficial : Accompanies sural nerve to end in skin.

Superior genicular—Medial: Arises just above condyles of femur, courses transversely around femur beneath semimembranosus and tendon of adductor magnus to front of knee, ending in vastus medialis and joint; *anas.* descending and lateral superior genicular.

Lateral: Winds beneath biceps, perforates intermuscular septum; *anas.* descending branch of lateral circumflex, lateral of descending and medial superior genicular, forming an arch across femur, lateral

inferior genicular; supplies joint by superficial and deep branches.

Inferior genicular—Medial: Passes down on medial condyle of tibia, beneath medial head of gastrocnemius and medial ligament; *anas.* opposite artery, medial superior genicular, anterior tibial recurrent.

Lateral: Courses laterally under lateral head of gastrocnemius, plantaris and lateral ligament, runs forward along lateral semilunar cartilage; *anas.* in front with other genicular branches, anterior tibial recurrent.

Middle genicular: Arises opposite flexure of joint, pierces oblique popliteal ligament, supplying cruciate ligaments and other structures in the joint.

THE ANTERIOR TIBIAL ARTERY

Extent: From division of popliteal artery at lower border of popliteus to front of ankle, where it becomes dorsalis pedis.

Course: At first directed slightly laterally, it passes forwards, between two heads of origin of tibialis posterior, to reach anterior surface of interosseous membrane; thence a line drawn from medial side of head of fibula to midway between the two malleoli will mark its course.

Relations: Lies deeply on interosseous membrane; tibialis anterior to medial side, the extensor digitorum longus above, and the extensor hallucis longus below upon its lateral side; covered below by extensor retinacula and crossed by extensor hallucis longus tendon; rests below upon the anterior surface of the tibia. It is accompanied by two venæ comitantes. Anterior tibial nerve lies at first lateral, then becomes superficial, and below is again lateral.

Branches

Posterior tibial recurrent: Passes upwards deep to popliteus to back of knee.

Circumflex fibular: Passes round neck of fibula, through soleus, to peroneus longus.

Anterior recurrent: Arises as artery reaches anterior surface of interosseous membrane, passes in tibialis

anterior to lateral and anterior surfaces of knee-joint; *anas.* genicular of popliteal.

Lateral and medial anterior malleolar: Two in number, arise just above ankle-joint, supplying it.

Medial: Passes beneath extensor hallucis longus and tibialis anterior tendons to medial malleolus; *anas.* branches of posterior tibial.

Lateral: Passes laterally beneath extensor digitorum longus and peroneus tertius; *anas.* perforating branch of peroneal, tarsal of dorsalis pedis.

Muscular: To surrounding muscles.

DORSALIS PEDIS ARTERY

Extent: From front of ankle to proximal part of 1st interosseous space, ending by anastomosing with lateral plantar artery to form plantar arch after it has entered sole between heads of origin of 1st dorsal interosseous muscle (*cf.* radial artery, p. 155).

Relations: Lies between tendons of extensor hallucis longus and extensor digitorum longus; near termination it is crossed by tendon of extensor hallucis brevis. Bound down by fascia lying on talus, navicular, and intermediate cuneiform. Accompanied by two venæ comitantes. Anterior tibial nerve lies to lateral side

Branches

Tarsal: Arises as artery crosses navicular, courses forwards and laterally beneath extensor digitorum brevis, supplying it, then backwards to cuboid; *anas.* lateral plantar, arcuate, lateral malleolar, perforating of peroneal.

Arcuate: Arises near bases of metatarsals, directed laterally in an arched direction, beneath short extensor of toes to lateral side of foot, over bases of metatarsal bones; *anas.* tarsal, lateral plantar. From the convexity of arch proceed three *dorsal metatarsal* branches to three lateral metatarsal spaces. They supply the interossei and divide at cleft of toes into digital branches; the most lateral one supplies also lateral side of little toe. Each dorsal metatarsal artery communicates at the cleft of the toes with a

- plantar digital by an *anterior perforating* branch, and at the back of the interosseous space with the plantar arch by a *posterior perforating* branch.

- **1st dorsal metatarsal** : Arises as dorsalis pedis is about to dip down into sole. It lies over dorsum of 1st interosseous space, and divides at cleft to supply contiguous sides of 1st and 2nd toes, having previously given off a branch to medial side of great toe.

1st plantar metatarsal, or arteria magna hallucis : Arises in sole from dorsalis pedis at junction with plantar arch, passes forwards in 1st interosseous space to cleft, where it divides into two branches for contiguous sides of 1st and 2nd toes, having previously given off a branch to medial side of great toe.

THE POSTERIOR TIBIAL ARTERY

Extent : From lower border of popliteus to lower edge of flexor retinaculum of ankle, there dividing into medial and lateral plantar, at a spot midway between medial malleolus and medial border of heel.

Course : At first midway between tibia and fibula; afterwards approaches tibia and lies on it.

Relations : Upper $\frac{2}{3}$ covered by gastrocnemius and soleus. Lower $\frac{1}{3}$ superficial between medial border of tendo-calcaneus and medial border of tibia. Posterior tibial nerve is at first on medial side, but within 2 inches of origin crosses posteriorly to reach lateral side. Has venæ comitantes, and lies on tibialis posterior, flexor digitorum longus, tibia, and back of ankle-joint.

Relations of artery at medial malleolus, from medial to lateral: Tibialis posterior and flexor digitorum longus tendons, vein, artery, vein, nerve, flexor hallucis longus tendon

Branches

Peroneal : Arises 1 inch from popliteus, courses obliquely to fibula, then along medial border of that bone, between origins of tibialis posterior and flexor hallucis longus to lower part of interosseous membrane, where it gives off a *perforating branch*, and is continued over inferior tibio-fibular articulation to

lateral side of lateral malleolus, where it ends by *anas.* with lateral plantar and tarsal. Covered in upper part by soleus and deep fascia, then by flexor hallucis longus. Beyond the malleolus it is superficial.

Branches of peroneal

Muscular : To soleus, tibialis posterior, flexor hallucis longus, and peronei.

Nutrient : To the fibula, passes downwards.

Perforating branch : Arises about 2 inches above lateral malleolus, pierces or passes below interosseous membrane, and under cover of peroneus tertius reaches front of lateral malleolus and tarsus, supplying ankle-joint; *anas.* lateral malleolar, tarsal of dorsalis pedis, and terminal of peroneal.

Communicating : To join communicating of posterior tibial.

Muscular : To soleus, and deep muscles of back of leg.

Nutrient : To tibia, arises near origin of posterior tibial, largest of kind in body, passes downwards.

Communicating : Arises 2 inches above medial malleolus, courses beneath flexor hallucis longus; *anas.* communicating of peroneal.

Calcaneal : Arises near termination, pierces flexor retinaculum with medial calcaneal nerve, to supply skin, fat of heel, and muscles on medial side of foot.

MEDIAL PLANTAR ARTERY

The smaller terminal branch of the posterior tibial, directed forwards along medial border of foot as far as base of 1st metatarsal bone, thence along medial side of great toe to anastomose with 1st plantar metatarsal, is covered at first by abductor hallucis, and subsequently becomes more superficial, lying between that muscle and the flexor digitorum brevis; it has medial plantar nerve lateral to it.

Branches

Digital : To clefts between three medial toes, joining digital branches from plantar arch.

- **Cutaneous**: To medial side and sole of foot.
- **Muscular**: To muscles of medial side of sole.

LATERAL PLANTAR

- From medial part of foot, beneath abductor hallucis, it runs lateral to lateral plantar nerve, between flexor digitorum brevis and flexor digitorum accessorius, to base of 5th metatarsal; thence it passes medially, resting on the interosseous muscles and deep to flexor tendons and lumbricals to the back part of the 1st interosseous space, and anastomoses with dorsalis pedis, completing plantar arch.

The **plantar arch** is placed across the tarsal end of the metatarsus, and is accompanied by the deep branch of the lateral plantar nerve.

Branches from the plantar arch

Recurrent: Small branches passing back to tarsal joints; *anas.* branches of medial plantar.

Posterior perforating (3): Ascend to dorsum of foot through posterior part of three outermost interosseous spaces; *anas.* dorsal metatarsal of arcuate.

Plantar metatarsal (4): Supply both sides of three lateral toes and lateral half of 2nd (*plantar digitui*); medial three bifurcate at the cleft of toes; give off at point of division, *anterior perforating* to *anas.* with dorsal metatarsal arteries.

The Veins

THE VEINS OF THE HEAD AND NECK

The veins of the brain have no valves, and owing to the absence of muscular tissue their walls are very thin.

Cerebral may be divided into superficial, which lie in sulci on the surface of the hemisphere; and deep, which issue from the substance of the brain.

The superficial veins are divisible into three sets: superior (10 to 12 on each side), which pass forwards and medially to superior sagittal sinus; inferior, of which three are large—viz. *superficial middle cerebral*, drains surface of temporo-sphenoidal lobe, runs along lateral cerebral fissure to cavernous sinus; often connected with superior sagittal sinus by *superior anastomotic vein*, and may communicate with transverse sinus through *inferior anastomotic vein*, and medial—*deep middle cerebral vein* on insula, joined by *anterior cerebral* and *striate veins* at anterior perforated substance to form basal vein. *Basal vein* winds around cerebral peduncle, collecting thalamic veins from posterior perforated substance, meets great cerebral vein and inferior sagittal sinus at commencement of straight sinus.

The deep veins are the *choroid vein*, which drains choroid plexus of lateral ventricle, unites with veins of septum lucidum and *thalamo-striate* to form *internal cerebral vein* near interventricular foramen; the right and left internal cerebral veins run back between layers of tela choroidea of 3rd ventricle, below splenium of corpus callosum, to form *great cerebral vein*, which emerges from transverse fissure to enter anterior end of straight sinus.

Cerebellar : Superior and inferior; the former open into straight, the latter in transverse and superior petrosal sinuses.

Sinuses : Structure like veins of brain; situated between two layers of dura mater. *Superior sagittal* : Begins above crista galli, runs back in upper border of falx cerebri to confluence of sinuses, usually joining right transverse sinus; receives superior cerebral, parietal and emissary veins. Intersected by fibrous trabeculae; the lumen is triangular, and on either side open the *lacunae laterales*. Receives arachnoid granulations.

Inferior sagittal : Along posterior $\frac{2}{3}$ of free margin of falx cerebri to straight sinus. Receives from medial surface of hemispheres.

Straight : Is placed at junction of tentorium and falx cerebri, goes to confluence of sinuses, ending usually in left transverse sinus; receives inferior sagittal sinus, great cerebral, basal, and superior cerebellar veins.

Transverse (2) : From confluence of sinuses runs to lateral angle of occipital between layers of tentorium, then as *sigmoid sinus* curves down on mastoid to jugular foramen, at exit from which it becomes internal jugular vein; each receives superior petrosal sinus, and mastoid vein and inferior petrosal sinus just below jugular foramen; the right also receives the superior sagittal and the left the straight sinus.

Occipital (2) : Smallest. From confluence of sinuses runs in falx cerebelli, divides around foramen magnum to enter termination of sigmoid sinus. May be double.

Cavernous (2) : By side of sella turcica, passes from superior orbital fissure to apex of petrous part of temporal. Receives ophthalmic veins which connect the anterior facial vein with this sinus; also superficial middle cerebral veins and sphenoparietal sinus. The ophthalmic veins are two in number: *superior*, the larger, accompanies artery; and *inferior*, running below optic nerve, is formed by lower ciliary and muscular branches, and communicates through inferior orbital fissure with pterygoid plexus; both

pass through the superior orbital fissure to empty into the cavernous sinus

Cavernous sinus broken into multiple small venous channels by honeycomb of fibrous septa. Through the sinus run internal carotid artery (S-bend), sympathetic plexus and 6th nerve. In lateral wall lie 3rd, 4th and ophthalmic and maxillary divisions of 5th nerve.

Intercavernous : Surrounds pituitary body, connects the cavernous sinuses.

Inferior petrosal (2) : From termination of cavernous to internal jugular vein, lies over petro-occipital suture.

Basilar : A network of sinuses which connect the inferior petrosal sinuses across basilar process of occipital bone.

Superior petrosal (2) : Placed on superior border of petrous part of temporal, connecting transverse and cavernous sinuses; receives inferior lateral cerebral, internal auditory and anterior lateral cerebellar veins.

Spheno-parietal : Receives some meningeal and inferior cerebral veins, and runs medially along free margin of lesser wing of sphenoid to cavernous sinus.

Veins of the diploë : Lodged in channels of the bones of the cranial vault. They are divided into *frontal*, joining the supra-orbital vein, *anterior parietal*, joining a deep temporal vein; *posterior parietal*, joining transverse sinus; and *occipital*, joining occipital vein or transverse sinus.

Emissary veins : Small veins passing through foramina in the bones, and connecting the sinuses with the external veins of the head.

THE VEINS OF THE FACE, SCALP AND NECK (Fig. 43)

Facial (anterior facial) : Passes obliquely across side of face from medial angle of orbit to anterior border of

Maxillary : Is formed by tributaries corresponding with the branches of the maxillary artery; they form a plexus (*pterygoid*) placed around and within lateral pterygoid muscle. The trunk of the vein passes backwards with artery to neck of mandible to join temporal vein and form retromandibular (posterior facial) trunk.

The pterygoid plexus is formed by

middle meningeal (2).
 deep temporal.
 veins of pterygoid canal.
 masseteric.
 infra-orbital
 buccal
 spheno-palatine.
 inferior dental
 greater palatine.

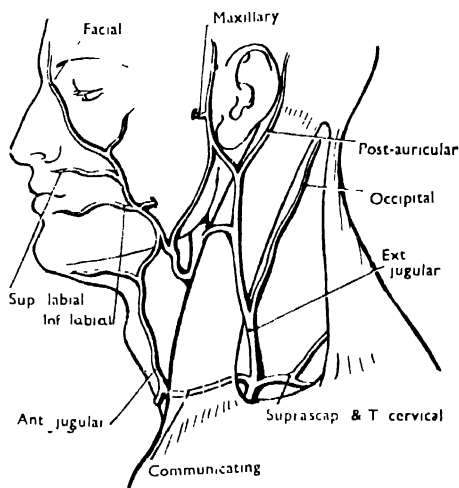


FIG. 43.—THE SUPERFICIAL VEINS OF THE FACE AND NECK.

The pterygoid plexus communicates with inferior ophthalmic vein and with the facial vein by the *deep facial* vein and with cavernous sinus via foramen ovale or foramen of Vesalius.

Retromandibular (posterior facial) vein : Formed by union of superficial temporal and maxillary veins; descends in parotid gland on external carotid artery and, crossed by facial nerve, divides into two branches: anterior, which unites with the (anterior) facial, and posterior, which receives the posterior auricular vein to form the trunk of the external jugular vein.

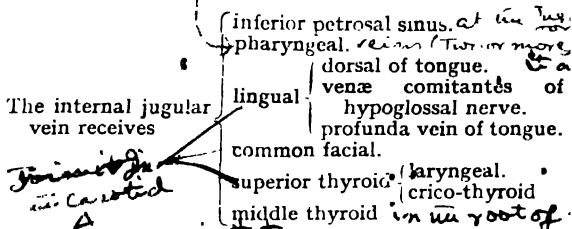
Posterior auricular : From plexus on side of head and back of ear, receives stylo-mastoid vein, and branches from external ear; joins with posterior division of retromandibular to form external jugular vein. Communicates with sigmoid sinus by *mastoid emissary vein*

Occipital : From plexus in superficial fascia at back part of scalp, where vein has same course as artery; it then passes deeply under semispinalis capitis, over suboccipital triangle, where it communicates with vertebral, and passes on semispinalis cervicis into deep cervical vein.

External jugular : Formed by junction of posterior division of retromandibular trunk and posterior auricular vein at angle of mandible in the substance of parotid. Descends beneath platysma over sterno-mastoid, pierces cervical fascia above middle of clavicle to open into subclavian, or occasionally into the internal jugular. Has two pairs of valves. Receives *posterior external jugular*, draining superficial region at back of neck, *suprascapular*, *transverse cervical*, and the *anterior jugular*.

Anterior jugular : Drains skin and superficial muscles of submental region; reaching suprasternal notch, communicates with fellow (jugular arch) and passes laterally under sterno-mastoid to end in external jugular.

Internal jugular : ^{① Begins in the} ~~From jugular foramen~~, being continuation of sigmoid sinus. ② Passes vertically down the side of neck, lateral to internal and common carotid arteries (see p. 135), uniting with subclavian near the medial margin of the scalenus anterior to form the innominate vein. Usually crossed by accessory and descendens cervicalis nerves. One pair of valves placed $\frac{3}{4}$ inch above termination.



Vertebral: No vertebral vein inside skull. Communicates with posterior spinal and occipital veins; starts in occipital region and drains deep muscles of back of neck; enters foramen in transverse process of atlas, runs down in front of artery through foramina transversaria of the cervical vertebræ to 6th (or 7th), where it passes down to enter innominate vein. One pair of valves guard its mouth

The vertebral vein receives { muscular
spinal.
anterior vertebral.
deep cervical.
1st intercostal

Deep cervical: Corresponds to deep cervical artery; lies deeply in neck; above receives occipital and ends in vertebral.

THE VEINS OF THE UPPER EXTREMITY

A. SUPERFICIAL, LYING ON DEEP FASCIA

Dorsal venous arch: Behind metacarpal heads, receives bulk of blood from palm, whence pressure of gripping drives it. Drains into basilic and cephalic veins, most into former.

Radial: From dorsum of the thumb, radial side of index-finger and hand, along lateral side of forearm to join median cephalic near bend of elbow, and form the cephalic vein.

Median: From palmar surface of hand up the middle of forearm, communicating below the bend of elbow with venæ comitantes of ulnar, and then divides into median cephalic and median basilic.

Median basilic: Passes obliquely medially over bicipital aponeurosis, which separates it from the brachial artery. Empties into basilic. Receives large tributary from depths of cubital fossa.

Median cephalic: Passes obliquely laterally from bend of elbow, between brachio-radialis and biceps. Empties into cephalic.

Basilic: Pierces deep fascia in lower $\frac{1}{3}$ of arm, and ascends on the medial side to lower border of subscapularis, where it joins brachial venæ comitantes to form axillary vein.

Cephalic: Passes up between deltoid and pectoralis major, perforates deep fascia and clavipectoral fascia, and opens into the axillary vein. It is occasionally connected with the external jugular by a branch over the clavicle (*jugulo-cephalic*).

B. DEEP VEINS ACCOMPANYING THEIR RESPECTIVE ARTERIES AS VENÆ COMITANTES, INTERCOMMUNICATING WITH EACH OTHER AND THE SUPERFICIAL VEINS FREQUENTLY

Digital (2): Empty into the superficial palmar.

Superficial palmar (2): Empty into ulnar and radial.

Deep palmar: Empty into radial venæ comitantes.

Interosseous (2): Accompany the anterior and posterior interosseous arteries, commencing at the wrist, terminating in venæ comitantes of the ulnar.

Comitantes radiales (2): Form, with the ulnar, the comitantes of brachial.

Comitantes ulnares (2): With the radial, form comitantes of brachial.

Comitantes brachiales (2): Receiving veins corresponding to the branches of the brachial artery, empty into the axillary vein.

Axillary (single): Formed by junction of brachial veins with the basilic. Commences at lower border of the subscapularis; receives veins corresponding to branches of its artery, and terminates in the sub-

clavian at lateral border of 1st rib. [Valves at inferior border of subscapularis, terminations of subscapular and cephalic veins.]

Subclavian : Continuation of axillary, joins internal jugular vein behind the medial end of the clavicle to form innominate vein. Separated from its artery by scalenus anterior muscle and phrenic nerve. Receives external jugular vein. [Valves just lateral to entrance of external jugular, or about 1 inch from its termination.]

THE VEINS OF THE BODY

Brachio-cephalic (innominate): Two large trunks, formed by the junction of the internal jugular and subclavian veins of the corresponding side. They end by uniting to form the superior vena cava. No valves.

The right vein is 1 inch long, and, formed behind the medial end of the right clavicle, passes downwards to join left innominate at the inferior border of 1st right costal cartilage. Receives the right vertebral, right internal mammary, right inferior thyroid, and 1st right intercostal veins. The right lymphatic duct opens at the angle of union of right subclavian and internal jugular veins

The left vein is 3 inches long, passes from left to right and downwards. The thoracic duct opens at the angle of union of the left subclavian and internal jugular veins.

The left brachio-cephalic vein receives	{	left vertebral left internal mammary. left inferior thyroid. first left intercostal left superior intercostal. thymic. mediastinal. pericardiaco-phrenic.
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Internal mammary : Two with each artery, uniting in a single trunk, emptying into brachio-cephalic veins.

Inferior thyroid (sometimes 3 or 4): From thyroid

venous plexus, emptying into right and left innominate veins.

Intercostal : Eleven on each side; run above corresponding arteries in intercostal space. The *first intercostal* passes up over neck of 1st rib and over pleura to end in brachio-cephalic.

The right second and third intercostal veins join as *right superior intercostal*, which ends in azygos.

The corresponding vein on the left receives left bronchial vein and passes forward across arch of aorta to left innominate vein. (For other intercostal veins see Vena azygos. below.)

Superior vena cava : 3 inches long, formed by the junction of the right and left innominate veins behind the junction of the 1st right costal cartilage with the sternum; passes down to the right atrium opposite upper border of 3rd right costal cartilage. The vena cava enters the pericardium about $1\frac{1}{2}$ inches from its termination, and this part is covered with serous membrane except posteriorly. No valves. Receives pericardiac and mediastinal veins and, just as it enters the pericardium, the azygos vein

Vena azygos : Commencing opposite 1st or 2nd lumbar vertebra by a branch from right lumbar veins, passes up through aortic opening in diaphragm to right of aorta, and along right side of vertebral column in front of right intercostal arteries to 5th thoracic vertebra, where, arching over root of right lung, it empties into superior vena cava. Receives the eight lower right intercostal veins, right superior intercostal vein, superior and inferior venæ hemiazygos, several œsophageal, mediastinal, and right bronchial veins. Imperfect valves, though its tributaries have complete ones.

Inferior vena hemiazygos : Commencing in lumbar region of left side from lumbar veins, or branches of renal, passes through left crus of diaphragm to 8th thoracic vertebra, there crossing behind aorta and thoracic duct to terminate in vena azygos. Receives three or four lower left intercostals; some œsophageal and mediastinal veins.

Superior vena hemiazygos : Formed by union of 4th, 5th, 6th, 7th, and 8th left intercostal veins; communicates above with superior intercostal vein, crosses 7th thoracic vertebra behind aorta and thoracic duct to end in vena azygos.

Bronchial : From lungs; the right terminating in azygos, the left in the left superior intercostal or hemiazygos

SPINAL—External vertebral plexuses : Extend along whole length of spine, forming network upon bodies of vertebrae in front and upon neural arches behind; terminate in the vertebral (of neck), the intercostal (of thorax), lumbar and sacral veins.

Internal vertebral plexuses : Situated between vertebra and dura mater, consisting of *longitudinal vertebral plexuses*, *anterior* and *posterior*, which run whole length of vertebral canal; both sets terminate in external plexuses.

Veins of the vertebrae — Basivertebral veins : From bodies of vertebrae, terminating in anterior longitudinal, very large, having supplied active red marrow.

Veins of the spinal cord : Cover cord, between pia and arachnoid, from conus to occipital bone; drain along nerve roots to segmental veins (vertebral, intercostal, lumbar, lateral sacral). No valves in any of the spinal veins.

Inferior vena cava : Formed by junction of the two common iliac veins a little to the right in front of 5th lumbar vertebra behind right common iliac artery, passes up on right side of aorta to posterior border of liver, where it becomes embedded in a groove and receives the hepatic veins; thence it goes through vena caval opening in diaphragm between middle and right leaflets at level of 8th thoracic vertebra behind 6th right costal cartilage, enters pericardium, and opens into lower and back part of right atrium, its orifice being protected by the imperfect valve of inferior vena cava.

<i>Anterior.</i>	<i>Relations</i>	<i>Medial.</i>
Mesentery.	Vertebral column.	Descending aorta
Third part of duodenum.	Right crus of diaphragm and psoas.	Right crus
Pancreas.	Right sympathetic trunk	
First part of duodenum.	Right renal	} arteries
Opening into lesser sac.	Right lumbar	
Portal vein.	Right suprarenal	
Posterior surface of liver.	Right inferior phrenic	
Hepatic	Right suprarenal gland.	
Right testicular		
Right colic		
Right common iliac		
Diaphragm.		
	lumbar branches.	
	right testicular.	
	(ovarian in female)	
	right renal	
	left renal	left testicular.
		left suprarenal.
	right suprarenal	
	phrenic.	
	hepatic.	

The inferior vena cava
receives

Pulmonary : Four in number; commence in capillary network upon the pulmonary alveoli, uniting to form a trunk for each lobe; the vein of the middle lobe of the right lung unites with that of the superior lobe, hence there are two veins on each side. No valves. Carry oxygenated blood and empty into the left atrium, the left veins crossing the descending thoracic aorta; the right pass behind the right atrium and inferior vena cava.

Cardiac : (see p. 128).

THE PORTAL SYSTEM

The veins of the portal system, which collect the blood from the digestive tract, are valveless. They form a trunk, the **portal vein**, which enters the liver and breaks up into small branches in its substance. Having passed through capillaries in the bowel wall, the blood again passes through capillary-like vessels, termed sinusoids, in the liver. Oxygen to liver substance is supplied by hepatic artery, and blood from both hepatic artery and portal vein is carried into

inferior vena cava by hepatic veins. The following veins form the portal system:

Inferior mesenteric : Drains upper two-thirds anal canal, rectum, pelvic colon, descending colon and left half of transverse colon. It lies to the left of its artery, and passes near the duodeno-jejunal flexure, in anterior fold of para-duodenal fossa; then, passing behind pancreas, and over left kidney, opens into the splenic vein. Receives superior and inferior left colic and superior rectal veins. (The rectal tributaries anastomose with the rectal tributaries of the internal iliac.)

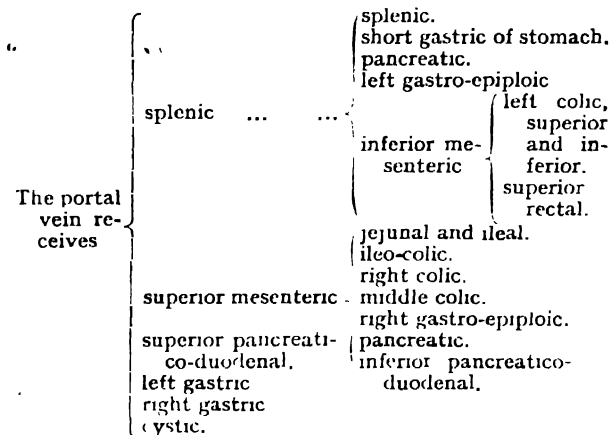
Superior mesenteric : Drains small intestines, cæcum, ascending and right half of transverse colon. It passes upwards in front and to right of superior mesenteric artery, in front of third part of duodenum and behind neck of pancreas; joins the splenic vein behind the upper border of the pancreas to form the portal vein. Receives jejunal, ileal, right gastro-epiploic, middle colic, inferior pancreatico-duodenal, right colic and ileo-colic veins.

Splenic : Commences in five or six tributaries in hilum of spleen; these unite to form a trunk which passes below splenic artery from left to right, behind pancreas, and in front of superior mesenteric artery; joins superior mesenteric vein at a right angle. Receives pancreatic, short gastric, left gastro-epiploic and inferior mesenteric veins.

Left gastric : A large vein accompanying left gastric artery from right to left along lesser curvature of stomach to cardia, where it receives œsophageal tributaries (*anastomosis with systemic circulation*) and passing to right behind lesser sac, opens into the portal vein.

Portal vein : Is formed by the union of the splenic, and superior mesenteric veins in front of the right crus of diaphragm and inferior vena cava, and behind the neck of the pancreas. Passes up behind first part of duodenum and then between the layers of the lesser omentum, behind and between the bile-duct and hepatic artery, the duct being placed on the right and artery on the left, to porta hepatis; here it divides into right and left branches to corresponding lobes,

and also gives an offset to the caudate lobe. Connected with the branch to the left lobe are the *ligamentum teres of liver* (*obliterated umbilical vein*) in front and the *ligamentum venosum* (*ductus venosus*) behind, the remains of a foetal connection with the inferior vena cava.



THE VEINS OF THE LOWER EXTREMITY

SUPERFICIAL SET

Dorsal venous arch : Behind heads of metatarsals, receives most of blood from sole of foot, whence pressure drives it through interosseous spaces.

Long saphenous : From arch on dorsum of foot; ascends in front of medial malleolus, accompanied by saphenous nerve; bends behind medial condyle of femur, ascends along medial side of thigh to $1\frac{1}{2}$ inches below inguinal ligament, where it receives *superficial circumflex iliac*, *superficial epigastric*, and *superficial external pudendal*, then passes through saphenous opening, empties into femoral. Communicates with deep veins, especially in soleus muscle. Through these, and other communicating veins above the knee, blood flows from superficial to deep. Has many valves.

Short saphenous : From plexus on dorsum and lateral side of foot, up behind lateral malleolus to median line of calf, accompanied by sural nerve; empties into popliteal vein, between the heads of the gastrocnemius. Two valves, one near termination. Communicates with deep veins of foot and with long saphenous.

DEEP SET

Posterior tibial : Two venæ comitantes, formed from *lateral* and *medial plantar*, joining with the *peroneal*. Course same as artery.

Anterior tibial : Two venæ comitantes, continuation of *dorsal veins of foot*, pierce interosseous membrane at upper part of leg, and form the popliteal vein, by junction with the *posterior tibial* veins, at the lower border of the popliteus muscle.

Popliteal (see anterior tibial) Passes up to femoral aperture in adductor magnus, there becoming the femoral, receives *sural* and *genicular* veins. Four valves. Placed superficial to artery, which it crosses as it ascends, from medial to lateral.

Femoral (see above) : Passes from the opening in the adductor magnus up to inguinal ligament, there becoming external iliac. Lies at first lateral to artery, but higher up crosses behind to its medial side. Receives *muscular* branches, *profunda femoris*, and the *long saphenous*. Four or five valves. Femoral canal, medial to it in femoral sheath, provides space for expansion of vein during increased blood flow.

External iliac (see above) : From inguinal ligament to lumbo-sacral articulation, there uniting with the internal iliac to form common iliac. On *right* side, lies medial to artery at first, but gradually passes behind it. On *left* side, medial to artery. Receives *inferior epigastric* and *deep circumflex iliac*, and a *pubic* vein from the obturator.

Internal iliac : Formed by the union of all of the venæ comitantes of the branches of the internal iliac artery, except the ilio-lumbar veins, which open into the common iliac. It lies at first on the medial side,

but finally gets behind the artery. It has no valves. The visceral veins opening into the internal iliac anastomose very freely and form a series of plexuses.

The internal iliac vein receives	visceral branches	rectal plexus	{ superior and middle rectal.
		vesico-prostatic plexus	vesical.
			dorsal of penis
			deep veins of penis
The internal iliac vein receives	parietal branches	uterine	} in female
		vaginal	
		obturator.	
		internal pudendal	deep veins of penis or clitoris.
			veins of bulb
			transverse perineal
			scrotal or labial.
		inferior gluteal	inferior rectal.
			coccygeal.
			companion vein of sciatic nerve
superior gluteal	muscular		
	lateral sacral.		

Common iliac (see external iliac): From ala of sacrum to terminate on 5th lumbar vertebra, a little to the right of the middle line behind right common iliac artery, where, with its fellow of opposite side, it forms inferior vena cava. The right vein is shorter, and nearly vertical. Receives *ilio-lumbar* and sometimes *lateral sacral* veins. *Middle sacral* empties into left common iliac. No valves.

Relations: *Right* vein passes behind, and then to right side of artery. *Left* vein is placed on medial side of left artery, and then passes behind right common iliac artery to join right vein, crossing middle sacral artery.

The Lymphatic System

The **thoracic duct** receives the lymphatics from both lower limbs, abdomen, except upper surface of liver, from left half of thorax, left upper limb, and left side of head and neck.

Length : 15 to 18 inches.

Extent : From 2nd lumbar vertebra, where it commences by a dilatation, the *cisterna chyli*, to junction of left internal jugular with left subclavian vein.

Relations : The abdominal part is placed on the front of the body of the 2nd lumbar vertebra, behind and to the right side of the aorta and on the medial side of the right crus, it then enters the thorax through aortic opening, on the right side of aorta, lying between it and the vena azygos, and passes upwards to right of aorta on right intercostal arteries and venæ hemiazygoi. By about the 4th thoracic vertebra it lies to the left behind aortic arch, and runs along the left side of the œsophagus, behind the left common carotid artery. At the level of the 7th cervical vertebra it turns laterally, and passing behind left internal jugular and crossing 1st part of left subclavian artery, arches over the apex of the left pleura, receives jugular and subclavian trunks, and opens at the angle of union of the left internal jugular and left subclavian veins. Often breaks into several terminal branches.

The right lymphatic duct : Receives the lymphatics of the right limb, right side of chest, right half of head and neck, and upper surface of liver. It is about $\frac{1}{2}$ inch long, and enters the venous system at the angle of union of the right internal jugular and right subclavian veins.

Other communications : Lymphatics communicate freely with veins throughout body (*e.g.*, thoracic duct can be ligated without harm).

Course of lymphatics : Superficial lymphatics follow veins, *deep lymphatics follow arteries*. Lymphatics richly supplied with valves, hence pulsation of nearby arteries aids lymph flow.

THE LYMPHATICS OF THE HEAD AND NECK

Superficial glands lie in a "collar" from chin to occipital region, *deep glands* lie vertically around carotid sheath.

SUPERFICIAL GLANDS

Suboccipital glands (1 or 2) : Receive lymphatics from back of scalp, efferent vessels join superficial cervical glands.

Mastoid glands (2 or 3) : Receive lymphatics from back of ear and external auditory meatus; efferent vessels join superficial cervical glands.

Parotid lymphatic glands (3 or 4) : One being placed just anterior to tragus. Receive lymphatics from temporal region, external auditory meatus and efferents, efferent vessels pass to submandibular and superficial cervical glands.

Deep facial glands : Afferent vessels from temporal, nasal, zygomatic, and orbital fossæ, palate and upper part of pharynx; efferent vessels pass to superior deep cervical glands.

Submental glands : Receive from tip of tongue, gums of mandibular incisors and corresponding part of lower lip, efferent vessels to submandibular lymph glands.

Submandibular lymphatic glands (8 to 10) : Afferent vessels from face, tongue, mouth, front of nasal cavities and sinuses, submandibular and sublingual glands, efferent vessels to cervical glands.

Superficial cervical glands (4 to 6) : Placed along the external jugular vein. Afferent vessels from external ear, skin of neck; efferent vessels to the deep cervical glands

DEEP GLANDS

Deep cervical glands (20 to 30)

Superior: Lie along internal jugular vein from division of common carotid to base of skull. Jugulo-digastric gland below digastric. Afferent vessels from deep facial and submandibular glands, cranium, tongue, larynx, lower part of pharynx, and thyroid gland. Efferent vessels to inferior set.

Inferior: Placed along lower part of internal jugular vein. Jugulo-omohyoid gland above omohyoid. Afferent vessels from other cervical glands and lower part of neck. Efferent vessels form a single trunk (*jugular lymphatic trunk*), opening into thoracic duct on left side, and into the right lymphatic duct on right side.

Lymphatics of tongue: Tip drains bilaterally to submental glands, sides homolaterally to submandibular glands, mid-line bilaterally to submandibular, posterior third bilaterally to jugulo-digastric and, especially, jugulo-omohyoid directly.

Lymphatics of face: Central part lower lip to submental glands, rest regionally to superficial glands.

Tonsils: And nearby tissues to jugulo-digastric (homolateral).

Thyroid gland: To regional glands from site of origin of *arteries* (i.e. anterior superior and posterior inferior deep cervical glands); many lymph vessels open directly into veins or thoracic duct.

Larynx: Above vocal fold to upper, below fold to lower, deep cervical glands, homolateral.

THE LYMPHATICS OF THE UPPER LIMB

(See Fig. 44)

The lymphatics of the arm are arranged in a superficial and a deep set which enter the axillary glands, except a few superficial which join the gland over the medial epicondyle.

There are two sets of lymphatic glands in the arm—viz. superficial and deep.

The superficial lymphatic glands : One or two above the medial epicondyle (*supratrochlear*).

The deep lymphatic glands : Two or three on medial side of brachial artery.

The axillary glands (10 to 12): Receive the lymphatics from the upper limb.

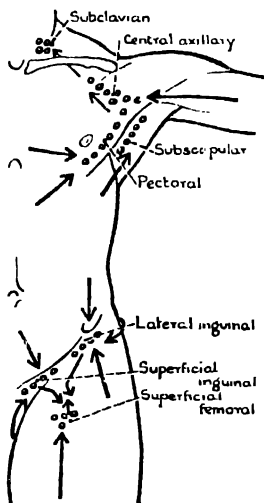


FIG. 11.—THE LYMPHATIC GLANDS OF THE AXILLA AND GROIN. The arrows indicate the direction of flow to and from the different groups of glands.

Lateral set : Placed medial to axillary vein; afferent vessels from limb.

Anterior or pectoral set : Placed along lateral thoracic artery; afferent vessels from mamma and anterior body wall above umbilicus.

Posterior or subscapular set : Placed along subscapular artery; afferent vessels from the back.

Infraclavicular set : On clavi-pectoral fascia, with a

few outlying members in delto-pectoral groove, receiving from radial border of limb and upper convexity of breast.

Central set : Small group in floor of axilla, draining hairy skin thereof.

Apical set : Lie behind clavicle, in apex of axilla. Receive from all other groups, and drain into sub-clavian lymph trunk.

Lymph drainage of breast : Essentially into pectoral group of axillary glands, the vessels running in pectoral fascia. In addition from periphery of breast lymphatics radiate (a) upwards to infraclavicular group, (b) medially to sternal group along internal mammary artery, and (c) downwards through abdominal wall to extraperitoneal lymphatics beneath diaphragm, thence to glands in mediastinum. Few channels via intercostal vessels to intercostal glands. Lymphatic plexuses, deep to breast in pectoral fascia, anastomose across front of sternum. Axillary tail, when present, drains directly into subscapular glands.

THE LYMPHATICS OF THE ABDOMEN AND PELVIS

Lymphatic system of abdomen and pelvis may be divided into:

(a) Lymphatic drainage of alimentary canal, including liver, spleen, pancreas—to *pre-aortic glands*.

(b) Lymphatic drainage of remaining organs and parietes—to *para-aortic glands*.

The system will be greatly simplified by recalling that the lymphatic vessels course centrally *along the arteries*.

Lymph drainage of alimentary canal : Adult retains blood supply of embryonic arrangement, where canal was slung by dorsal mesentery and its three parts supplied as follows:

Foregut (including liver, spleen,* pancreas) from coeliac axis.

Midgut from superior mesenteric artery.

Hindgut (including upper two-thirds of anal canal) from inferior mesenteric artery.

Lymph follicles present in mucous membrane of all parts of alimentary canal from tonsil to anal margin (including *oesophagus* and *stomach*). Microscopic size except in ileum, where aggregated into visible *Peyer's patches* lying longitudinally in anti-mesenteric border of ileum. From follicles efferent lymphatics to glands along alimentary attachments of mesenteries (e.g. *epicolic*), then glands in mesentery along arteries (e.g. *paracolic*), then to pre-aortic glands related to vessels concerned (Fig. 45).

Drainage of foregut: *Spleen* drains into hilar glands, which then drain to retropancreatic glands; latter drain the *pancreas*. Right end of retropancreatic chain joins with subpyloric group (draining pylorus and head of pancreas) to travel to celiac group. *Liver* drains into glands in porta hepatis, except bare area, which drains through diaphragm to posterior mediastinal glands. Lymphatics from porta hepatis follow hepatic artery to celiac glands. *Stomach* drains from lesser curvature by lymphoid follicles in mucous membrane, glands on lesser curvature, lymphatics along gastric arteries to celiac glands; from left side of greater curvature to splenic and retropancreatic glands, right side of greater curvature into subpyloric glands.

Drainage of midgut: From duodenal papilla to transverse colon, all drainage is via lymphoid follicles in mucous membrane, glands along gut border of mesentery, glands along vessels in mesentery to pre-aortic glands at origin of superior mesenteric artery, thence to celiac glands.

Drainage of hindgut: From splenic flexure to ano-cutaneous junction is the area of distribution of inferior mesenteric artery. Lymphatics follow it back from lymphoid follicles in mucosa, epicolic and paracolic glands to pre-aortic glands at origin of inferior mesenteric; efferents thence to celiac group. A few lymphatics from lower rectum follow middle rectal artery to glands on side wall of pelvis and median sacral artery to glands in hollow of

sacrum. NOTE.—Lower one-third anal canal drains to medial group of superficial inguinal glands.

Coeliac glands: Ultimately receive all lymph from alimentary canal; they drain into cisterna chyli.

Para-aortic glands: These lie (a) medial group alongside aorta, receiving from non-alimentary viscera and lower limb, and (b) lateral group behind psoas, receiving from abdominal parietes.

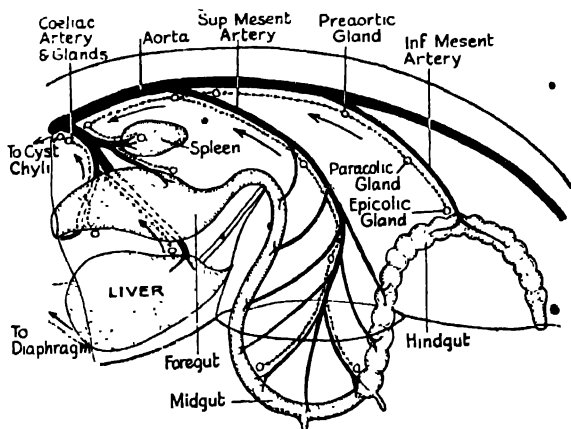


FIG. 15.—LYMPH DRAINAGE OF ALIMENTARY CANAL. Lymphatics follow back along the course of the arteries to hindgut, midgut and foregut to pre-aortic lymph glands.

Drainage of bladder (including prostate and lower ureter): Vessels pass with arteries to glands along internal iliac artery and pelvic wall.

Drainage of kidneys (including upper ureter): Vessels pass to para-aortic glands alongside L. 1 vertebra.

Drainage of testis: Vessels pass with arteries to para-aortic glands opposite L. 2 vertebra (an inch above umbilicus).

Drainage of uterus and ovary: Uterus to glands on side wall of pelvis (follow uterine artery), ovary

and ampulla of tube to para-aortic glands at origin of ovarian artery (same as testis).

THE LYMPHATICS OF THE THORAX

Sternal glands (6 to 10): Along internal mammary vessels. The afferents come from front of chest and abdominal wall, diaphragm and deep surface of mamma; the efferent vessels join anterior mediastinal glands and thoracic duct.

Intercostal glands: Placed posteriorly on heads of ribs. The afferent vessels come from chest wall; the efferent open into the thoracic and right lymphatic ducts.

Anterior mediastinal glands (3 or 4): Between pericardium and sternum. The afferent vessels come from lower sternal glands, upper surface of liver and diaphragm; the efferent vessels pass to thoracic and right lymphatic ducts.

Superior mediastinal glands (8 to 10): Placed in front of the arch of the aorta in the superior mediastinum. The afferent vessels come from the heart, pericardium and thymus gland; the efferent vessels unite in mediastinal trunks which open into the thoracic and right lymphatic ducts.

Bronchial glands: Are placed behind and between the bronchi. The afferent vessels come from the lung; the efferent vessels join to open into the mediastinal.

Posterior mediastinal glands (8 to 12): Lie along descending thoracic aorta. The afferent vessels come from the œsophagus, pericardium, and diaphragm; the efferent vessels go to the thoracic duct.

Pretracheal glands: Above bifurcation of trachea, drain trachea, upper œsophagus; efferent vessels to thoracic duct.

THE LYMPHATICS OF THE LOWER LIMB

(See Fig. 44, p. 198)

The lymphatics of the lower limb are divided into a superficial and a deep set. The *superficial*, except a few which pass to the popliteal glands, go to the super-

facial inguinal glands. The *deep* lymphatics enter the deep inguinal glands.

The popliteal glands (4 or 5): Are placed on the popliteal vessels. The afferent vessels come from the heel only; the efferents go to the deep inguinal glands.

The superficial inguinal glands (8 to 10).

Oblique set : Lie below inguinal ligament. *Lateral group* receive from flank and buttock; *medial group* from anterior abdominal wall below umbilicus, perineum, lower one-third anal canal and external genitalia including urethra. *Vertical or femoral set* : Lie along the long saphenous vein, and receive the superficial lymphatics of the limb. The efferent vessels of both sets join the deep glands, passing chiefly through saphenous opening.

The deep inguinal glands : Lie medial to femoral vein (a constant one in the femoral canal). The afferent vessels come from the superficial inguinal glands, the popliteal glands, and the deep lymphatics of the limb; the efferent vessels join the external iliac glands, which they reach by way of femoral canal.

The Nervous System

This is divided as follows:

Central nervous system: Spinal cord and brain.

Peripheral nervous system: Spinal nerves, autonomic system (sympathetic and parasympathetic).

THE CENTRAL NERVOUS SYSTEM

THE SPINAL CORD

The **spinal cord** is the elongated cylindrical part of the cerebro-spinal axis which occupies the upper $\frac{2}{3}$ of the vertebral canal—namely, from the foramen magnum to the *lower border of the first lumbar vertebra*. Up to the third month of foetal life the cord occupies the whole of the canal; at birth it extends to the 3rd lumbar vertebra.

CONTENTS OF THE VERTEBRAL CANAL

<i>Above 2nd Lumbar Vertebra</i>	<i>Below 2nd Lumbar Vertebra.</i>
Cord surrounded by membranes, including subarachnoid space and cerebro-spinal fluid.	Elongated anterior and posterior roots of spinal nerves from L. 2 downwards contained in membranes and cerebro-spinal fluid (the roots constitute the <i>cauda equina</i>).
Spinal vessels within membranes.	Internal vertebral plexuses.
Internal vertebral plexuses outside membranes.	Filum terminale
Soft fat outside dura mater	

NOTE.—**Lumbar puncture** is performed between the 3rd and 4th or 4th and 5th lumbar vertebrae.

Enlargements: The spinal cord presents two enlargements in spinal levels of brachial and lumbosacral plexuses. The upper or *cervical* extends from the 3rd cervical downwards to the 2nd thoracic vertebra. The lower or *lumbar* commences opposite

the 9th thoracic vertebra; is largest at the 12th thoracic, and thence tapers, forming the *conus medullaris*, from the tip of which the *filum terminale* descends.

The filum terminale : Passes from the end of the *conus medullaris* downwards in the middle of the *cauda equina*; becomes closely invested with dura mater opposite the 1st or 2nd sacral vertebra, and blends with the periosteum at the lower end of the sacral canal.

The nerve-roots : Consist of anterior and posterior bundles, 31 pairs (see p. 259).

The *anterior* roots are arranged irregularly along the side of the cord; the *posterior* roots issue in a straight line. A posterior root is distinguished from an anterior root by having a ganglion and by its larger size; the ganglia are situated in the intervertebral foramina.

The nerve-roots pass laterally to the intervertebral foramina, in which they unite to form the spinal nerves, those in the upper part passing almost transversely; below they pass more obliquely, until in the lower part of the canal their course is vertical. The collected bundles of nerve-roots at the termination of the cord form the *cauda equina*.

Cervical roots of accessory nerve emerge from upper five cervical segments behind ligamentum denticulatum and run upwards, joining together to pass through foramen magnum (p. 257).

Blood distribution to spinal cord by spinal arteries (p. 149) and spinal veins (p. 189).

FISSURES AND COLUMNS

Anterior median fissure : Along the anterior surface of the cord in the middle line. Extends into the substance of the cord for about a third of its thickness, but deeper below than in the upper part. Does not reach grey matter, its floor being formed by transverse band of white matter, the *anterior white commissure*. Lined with double fold of pia mater.

Posterior median sulcus : Shallow; from it a septum of neuroglia reaches down to grey matter.

Columns of the cord :

The cord, being divided into two lateral halves by the median fissures, is subdivided on each side by the nerve-roots into *anterior*, *lateral*, and *posterior* columns.

'The *posterior* column is subdivided by a groove (only found in the upper part of the cord), a little lateral to the posterior median fissure, into two columns, corresponding to the *fasciculus gracilis* and the *fasciculus cuneatus*

STRUCTURE OF THE SPINAL CORD (Fig. 46)

The spinal cord in transverse section consists of white matter externally and grey matter internally.

The grey matter : Consists of a crescent-shaped portion in each lateral half of the cord, united by an intervening process, the *posterior* or *grey commissure*.

Each crescent has two horns, an *anterior*, thick and short, not reaching the surface of the cord; and a *posterior*, long and slender, reaching to the origin of the posterior nerve-roots, just before which it becomes enlarged and less opaque, forming the *substantia gelatinosa*. The size of the grey crescents varies in different parts of the cord, being largest in the cervical and lumbar enlargements. In the thoracic region there is a projection of the grey matter on the lateral side of the crescent between the anterior and posterior horns, called the *lateral horn*. It contains connector cells of sympathetic *Dorsal nucleus* (Fig. 46), at base of posterior grey horn, is a relay station for anterior spino-cerebellar tract.

Central canal : Extends through the whole length of the cord in the middle of the posterior or grey commissure. It is lined with a ciliated epithelium. Opens above into the floor of the 4th ventricle.

The white matter : Encloses the grey matter in each lateral half of the cord, except where the posterior horn comes to the surface. The portion of white matter between the posterior or grey commissure and

the anterior median fissure constitutes the *anterior or white commissure* (Fig. 46).

Posterior white columns : (Fasciculi gracilis and cuneatus) are sensory (tactile exteroceptive and conscious proprioceptive).

Lateral white columns : Contain descending tracts

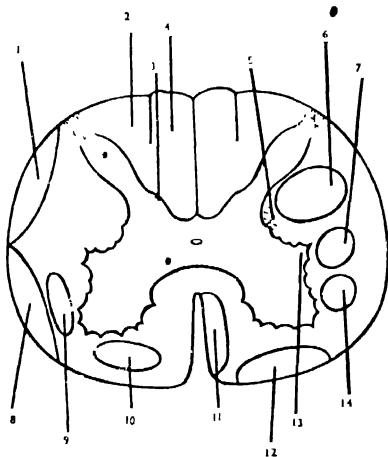


FIG. 46.--CROSS-SECTION OF SPINAL CORD.

In the white matter ascending tracts are shown on the left, descending tracts on the right. 1. Posterior spino-cerebellar tract. 2. Fasciculus cuneatus. 3. Dorsal nucleus. 4. Fasciculus gracilis. 5. *Formatio reticularis*. 6. Crossed pyramidal tract. 7. Rubro-spinal tract. 8. Anterior spino-cerebellar tract. 9. Lateral spino-thalamic tract. 10. Anterior spino-thalamic tract. 11. Direct pyramidal tract. 12. Vestibulo-spinal tract. 13. Lateral grey horn. 14. Tecto-spinal tract.

(crossed pyramidal and extrapyramidal) and ascending (spino-cerebellar and spino-thalamic). At junction of grey and lateral white columns lie scattered nerve cells known as *formatio reticularis*. The cells are intersegmental neurones.

Anterior white columns : Contain direct (uncrossed)

pyramidal tracts and vestibulo-spinal descending and anterior spino-thalamic ascending.

THE MEMBRANES OF THE SPINAL CORD

The DURA MATER is the most external membrane, and is continuous with that investing the brain; it differs, however, from the cranial dura mater in that it comprises a single layer, is devoid of sinuses, and is separated from the vertebræ by a space which contains much fat and the internal vertebral plexuses (p. 189). It is attached above to the edge of the foramen magnum and to the membrana tectoria, from the lower border of the 2nd sacral vertebra it is continued as a slender cord to blend with the periosteum of the coccyx. This membrane gives sheaths to all the spinal nerve roots.

The ARACHNOID MATER is placed outside the pia mater, and loosely invests the cord. Lies surface to surface with dura mater. The subarachnoid space of the cord is large, and is imperfectly divided by the ligamentum denticulatum into an anterior and a posterior portion. The posterior portion is further subdivided by the *posterior median septum*, which passes from the posterior fissure backwards to the opposite part of the arachnoid. Trabeculae also pass between the nerve-roots and the inner surface of the arachnoid.

The PIA MATER is less vascular, thicker, and more fibrous than that investing the brain. It has an external fibrous layer of longitudinal bundles having a fold, the *linea splendens*, dipping into the anterior fissure. The pia mater ends in the *filum terminale*, which lies within the prolongation of the dura mater. The *ligamentum denticulatum*, a process of pia mater, passes outwards towards the dura, to which it is attached by twenty-two tooth-like processes situated between the origins of the spinal nerve roots; its pial origin is continuous, and lies between the anterior and posterior nerve-roots.

THE BRAIN

The spinal cord is prolonged upwards to become the brain-stem; this consists from below upwards of the *medulla oblongata*, *pons*, and *mid-brain* (or *cerebral peduncles*) (Fig. 47, p. 210). The cerebral peduncles attach the cerebrum to the pons, and the *cerebellum* is attached to the pons and medulla by *cerebellar peduncles*.

THE MEDULLA OBLONGATA

Extent. From just below the foramen magnum to the lower border of the pons on the clivus.

Connections. Inferiorly it is continuous with the spinal cord, superiorly it is continued into the pons, anteriorly it rests upon the clivus, and posteriorly it lies in a depression between the hemispheres of the cerebellum, called the *vallecula of the cerebellum*, and here contains the lower half of the floor of the 4th ventricle.

Dimensions: $1\frac{1}{4}$ inches long; greatest breadth, $\frac{3}{4}$ inch.

Shape: Pyramidal, with base at the pons, and apex at the spinal cord. Lower half cylindrical, closed around central canal. Upper half conical, opened as part of fourth ventricle. (Figs. 47, 48).

Fissures: Anterior and posterior median fissures, continuous with those of the cord.

Anterior median fissure: Terminates just below the pons in the *foramen cæcum*. The fibres of the pyramids decussate at the lower part of the fissure, and partly interrupt it.

Posterior median fissure continues up from the cord to about half-way up the medulla, where it widens out into the floor of the 4th ventricle.

Structure of the medulla (Fig. 47): If the parts of the spinal cord are traced into the medulla, its structure will be easily understood.

The line of the posterior roots of the spinal nerves is continued by the upper bundles of the nerve-roots of the accessory nerve, above this by the bundles of the vagus, and above this, again, by the bundles of the glosso-pharyngeal nerve.

- These arise along a groove—the *postero-lateral sulcus*; traced upwards it turns ventrally outwards, so that, about half-way up the medulla it appears upon the lateral surface, and in its upper part it lies close to the posterior margin of the *olive*.

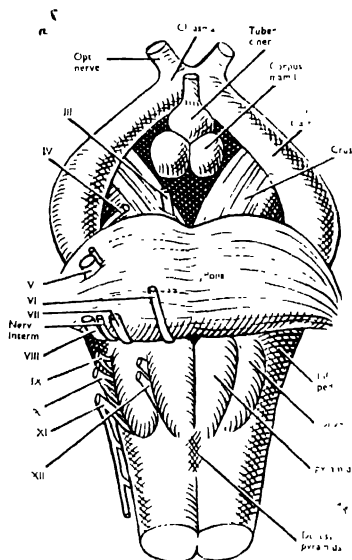


FIG. 47 — VENTRAL VIEW OF BRAIN STEM.

The part behind these nerve-roots is termed the *posterior region of the medulla*, and corresponds to the posterior columns (fasciculus gracilis and cuneatus) of the cord.

The line of the anterior roots of the spinal nerves, when traced up into the medulla, deepens into a groove (antero-lateral sulcus) which is continued upwards nearly as far as the pons.

The bundles of the nerve-roots of the hypoglossal

nerve spread out over its nucleus, which is continuous with the gelatinous matter of the medulla.

The inferior cerebellar peduncle : In the upper part of the medulla, a set of fibres issue from the anterior median fissure, pass transversely outwards over the pyramid and olive, and, continuing transversely, cross over the fasciculus gracilis and the fasciculus cuneatus, to turn upwards on these. They are the *external arcuate fibres*, and are derived from the gracile and cuneate nuclei of same and opposite side, emerge through, medial and lateral to the pyramid, arch over the olive, and join the inferior cerebellar peduncle. They are destined for the cortex of the cerebellum; joined to these, just above the tuberculum cinereum are some transverse fibres which come from the lateral column, known as the *posterior spino-cerebellar tract*. These oblique fibres blend with the superficial fibres of the fasciculus gracilis and fasciculus cuneatus, the whole forming the inferior cerebellar peduncle. Superiorly this diverges from its fellow to enter the cerebellum.

Lateral area of the medulla : The lateral column of the cord, as continued into the medulla, consists of three sets of fibres. One set, the *lateral cerebro-spinal tract*, passes obliquely downward from the opposite pyramid to continue down into the lateral white column of the cord. A second set consists of the *posterior spino-cerebellar tract* which joins the inferior cerebellar peduncle, whilst the rest of the column passes upwards as far as the lower end of the olive which conceals it.

The *olive* is an oval prominence lying in the upper part of the medulla, between the pyramid and the inferior cerebellar peduncle. It is separated from the pons by a groove, which contains some of the external arcuate fibres. On the medial side lie the nerve-roots of the hypoglossal; and on the lateral side, but separated from it by a groove, the roots of the accessory, vagus, and glosso-pharyngeal nerves issue.

Anterior area of the medulla : Most of the fibres of the anterior columns of the cord are uncrossed down-

ward projections from the pyramids. These fibres form the *pyramid*.

The **pyramids** are two oval prominences, broader above than below. They are placed one on each side of the anterior median fissure. They consist of two sets of fibres: medial, which when traced downwards decussate and pass to the lateral white column of the spinal cord as the lateral cerebro-spinal tract; and lateral, which do not cross the middle line, but descend into the anterior white column as the anterior cerebro-spinal tract. The crossing of the two sets of these former fibres constitutes the *decussation of the pyramids*.

The fourth ventricle: The central canal of the cord expands in the upper and posterior part of the medulla until opposite the middle peduncles of the cerebellum, where it again gradually narrows, and becomes continuous with the aqueduct of mid-brain above. The floor or anterior (ventral) wall of the ventricle is thus diamond-shaped. The lower end has been compared in shape to a pen, and is hence termed the *calamus scriptorius*.

BOUNDARIES OF THE FOURTH VENTRICLE

	<i>Laterally.</i>	<i>Floor.</i>	<i>Roof.</i>
<i>Above</i>	Gracile and cuneate tubercles.	Medulla (below).	Pia mater (below)
	Inferior cerebellar peduncle.		Inferior medullary velum.
			Nodule of inferior vermis.
	Superior peduncles of cerebellum.	Pons (above).	Superior medullary velum.
<i>Below</i>			Superior peduncles of cerebellum (above).
			Lingula of cerebellum.

The **floor** in the lower half is formed by the upper part of the posterior surface of the medulla, and in the upper half by the pons.

Structures on the Floor (Fig. 48, p. 211)

The floor is divided into right and left halves by a **median groove**. Each half shows the following structures:

In the lower part of the ventricle (medulla):

Fovea inferior: A triangular pit on each side of the median groove near the medullary striæ, the

apex being directed upwards. From the base, two grooves pass downwards, one towards the calamus scriptorius, and the other towards the lateral boundary. Three areas are thus marked off in each lateral half of the medullary portion:

1. **Hypoglossal triangle**: Next to groove—overlying nucleus of 12th nerve.

2. **Vagal triangle**: Lateral to above—overlying dorsal nucleus of 9th and 10th nerves.

3. **Vestibular area**: Lateral to these—overlying nuclei of vestibular nerve. This raised area extends up into the upper half.

Separating upper part of floor of ventricle from lower part.

4. **Medullary striæ**: Formerly believed auditory, these are now considered external arcuate fibres.

In upper part of floor (pons):

Fovea superior: A triangular depression in a line with the inferior fovea, dividing off each lateral half into two areas—viz.:

5. **Facial colliculus**: Produced by fibres of 7th nerve winding over nucleus of 6th nerve (Fig. 48).

6. Upper part of eighth nerve nucleus. Higher up is grey-blue area called *locus caeruleus*.

Structures beneath the Floor of the Ventricle

Trigeminal nuclei and tracts: *Principal* and *motor* nuclei in lateral part of upper half.

Descending spinal (protopathic) tract under floor of lower half.

Ascending mesencephalic (proprioceptive) under floor of upper half.

Nucleus ambiguus lies in the medulla in the formatio reticularis deep to the floor of the ventricle. It is the motor nucleus for swallowing (palate and stylopharyngeus) and vocalization (intrinsic muscles of larynx); fibres of the 9th, 10th and 11th nerves arise from it.

Superior salivatory nucleus alongside facial nucleus (pons); **inferior salivatory nucleus** runs down to 9th and 10th nuclei (medulla).

The **nucleus of the tractus solitarius** (taste 7th, 9th, 10th) also lies under the floor of the ventricle.

The **medial longitudinal bundle** lies on either side of the mid-line under the floor of the ventricle. It links up the nuclei of the 3rd, 4th, 6th and 11th with the vestibular nuclei and tectum.

Lateral recess : This is a lateral extension between the cerebellum and the medulla of the cavity of the ventricle at its widest part.

The roof : In the lower half is formed by pia mater, lined with ependyma. It has three apertures, one on each side in the lateral recess, and the third at the apex of the calamus scriptorius, the *median aperture of 4th ventricle*, by which the 4th ventricle communicates with the subarachnoid space.

The *inferior medullary velum* is a downward and forward extension of the white substance of the cerebellum on the pial covering of the ventricle. Projecting into the roof on each side of the middle line is the choroid plexus of the 4th ventricle.

In the upper half, the roof is formed by the converging superior peduncles of the cerebellum and the intermediate *superior medullary velum*, continuous with the white matter of the cerebellum (lingula).

THE PONS

Position : Placed above the medulla, below the cerebral peduncles, and between the lateral halves of the cerebellum (Fig. 47).

Dimensions : About $1\frac{1}{2}$ inches long, and about 2 inches transversely.

Ventral surface is convex, grooved along the mid-line by decussating ponto-cerebellar fibres; has transverse markings, and openings for the entrance of vessels.

Dorsal surface : Smaller than the anterior, and continuous with the posterior surface of the medulla; central part of it forms the upper part of the floor of the 4th ventricle (p. 214).

Laterally : Transverse fibres pass outwards and backwards from it, forming the middle cerebellar peduncles.

Upper border : Longer than the inferior, with a notch in the median line corresponding to the groove on the anterior surface.

Lower border : Slightly arched, overlapping the upper part of the medulla.

Structure : Alternating layers of transverse and longitudinal fibres, with intermingled grey matter (*nuclei pontis*). The transverse fibres are partly intercerebellar, and partly fibres which have come from the cerebrum and relayed in the nuclei of the pons before going to the cerebellum of the opposite side; the longitudinal are the continuation of the fibres of the medulla.

THE CEREBELLUM

The **cerebellum** is contained in the posterior fossa, being separated from the cerebrum above by the tentorium cerebelli. It consists of two *lateral hemispheres* and a median *vermis*.

The inferior surface of each hemisphere is boldly convex, and between them there is a fossa, the *vallecula*, at the bottom of which the inferior part of the vermis lies. The medulla is in contact with the anterior part of the vallecula, and the posterior part receives the *falx cerebelli*. The superior surface of each hemisphere is flat, and not clearly marked off from the vermis.

Lobes and fissures : The surface of the cerebellum is everywhere marked by shallow parallel *sulci* which demarcate the cerebellar *folia*. Certain of the furrows are deepened to form *fissures*, separating cerebellar *lobules*. The only significant subdivision of the cerebellum is into *antero-superior* and *postero-inferior lobes*; the fissure separating these is the *fissura prima*, which is a V-shaped fissure crossing the upper surface. The *flocculus* is a small projection from vermis which lies near lateral foramen of 4th ventricle, in the cerebello-pontine angle.

STRUCTURE

Grey matter : This covers the whole surface of the cerebellum, constituting the *cortex*. In addition there

are central nuclei embedded in the white matter; of these, the largest and most important is the bilateral **dentate nucleus**. Cerebellar cortex receives afferent fibres from spinal cord (proprioceptive from muscles, joints), vestibular nuclei (equilibrium) and from the cerebrum (extrapyramidal fibres from pre-motor cortex). It sends efferent fibres (axis cylinders of Purkinje cells which relay in dentate nucleus and again in red nucleus) to control muscle tone.

White matter: This forms a central stem which radiates out to the cortex, and also forms the *cerebellar peduncles* which connect the cerebellum to other parts of the brain stem.

Cerebellar peduncles: The *inferior* connects the cerebellum to the medulla; the *middle* connects the cerebellum to the pons; the *superior* connects the cerebellum to the mid-brain.

Principal constituent fibres of cerebellar peduncles:

Superior peduncle:

1. Afferent: Antero-lateral or indirect spino-cerebellar tract.
2. Efferent: From dentate nucleus to red nucleus of opposite side, and a few to thalamus.

NOTE.—The rubro-spinal fibres immediately decussate, so that ultimately cerebellar impulses are conveyed to the *same* side of the body.

Middle peduncle:

1. Fibres from grey matter of pons of opposite side (relay of extrapyramidal fibres from cerebral cortex).
2. Commissural fibres between cerebellar hemispheres.

Inferior peduncle:

1. Afferent: Posterior (direct) spino-cerebellar tract.
2. Afferent: Vestibulo-cerebellar fibres (impulses from labyrinth).
3. Afferent: External arcuate fibres from gracile and cuneate nuclei (proprioceptive).
4. Afferent: Olivo-cerebellar fibres.
5. Efferent: Cerebello-vestibular fibres.

THE MID-BRAIN (See Figs. 47, 48)

This comprises the two *cerebral peduncles* (which connect the pons to the cerebrum) and the *tectum* placed on the dorsal aspect of these.

The *cerebral peduncles* (or *cruva cerebri*) extend from the upper border of the pons and diverge into the cerebral hemispheres. Between them is the *interpeduncular space*, containing from behind forwards the posterior perforated substance, the mammillary bodies, hypophysis, infundibulum, and the tuber cinereum. Near the angle of divergence the roots of the oculo-motor nerve issue from a groove (*oculo-motor sulcus*) on the medial side of each peduncle. This groove indicates the separation of the

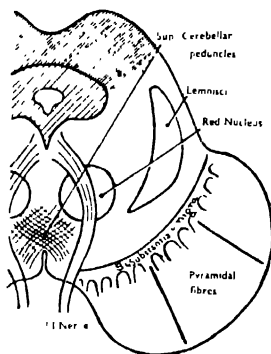


FIG. 50.—DIAGRAMMATIC SECTION THROUGH MID-BRAIN AT LEVEL OF SUPERIOR COLLICULI AND THIRD NERVE NUCLEI.

ventral part (*cruis*) from the dorsal portion (*tegmentum*) of the peduncle.

There is a layer of grey matter placed between the basis pedunculi and the tegmentum, known as the *substantia nigra*.

The *cruis* consists of descending white fibres, of which the middle third are continuous below with the pyramid of the medulla. Medial and lateral parts

contain cortico-pontine fibres. All these fibres have passed through the internal capsule.

The *tegmentum* consists of white ascending fibres and interspersed grey matter. Especially important ascending tracts are the *medial and lateral lemnisci* and the decussating *superior cerebellar peduncles* (see Fig. 50).

Running through the length of the mid-brain is the **aqueduct of mid-brain**, which connects the 3rd ventricle with the 4th. It is surrounded by grey matter, in which are the nuclei of the *3rd and 4th cranial nerves*. Lateral to the aqueduct is also found the *mesencephalic nucleus of the 5th nerve* in which the ascending fibres of this nerve end.

Third nerve nucleus lies in grey matter ventral to aqueduct, at level of superior colliculi. Cranial end of this nucleus contains parasympathetic cell bodies for ciliary muscle and sphincter pupillæ (p. 314). Fourth nerve nucleus lies, ventral to aqueduct, at level of inferior colliculi.

Level with superior colliculus tegmentum contains *red nucleus*, perforated by emerging 3rd nerve. Scattered masses of grey matter in tegmentum constitute the *reticular nuclei*, continuous with similar formation in pons, medulla and cord (p. 207).

The **tectum** consists of the two pairs of **colliculi (quadrigeminal bodies)** situated on the dorsum of the mid-brain, and divided off from one another by a cruciform groove. They are reflex centres. The superior pair receive fibres from the optic tract, and are a relay station for impulses from the optic nerves to the other cranial and spinal nerves. The inferior colliculus receives fibres of the auditory (lateral) lemniscus and relays to the other cranial and spinal nerves.

THE DIENCEPHALON

The **third ventricle** is the narrow median space between the thalami, extending from the opening of the aqueduct of the mid-brain under the posterior commissure to the interventricular foramen. It is much deeper in front than behind.

The third ventricle communicates above by the interventricular foramen with each lateral ventricle and behind with the 4th ventricle by the aqueduct of the mid-brain.

Boundaries

<i>Roof.</i>	<i>Floor.</i>	<i>Laterally.</i>
Formx.	Lamina terminalis.	Thalamus
Tela chorioidea with choroid plexus of 3rd ventricle.	Optic commissure.	† Peduncles of pineal body.
	Tuber cinereum.	Hypothalamus.
	Infundibulum	
	Manullary bodies.	<i>Anteriorly.</i>
<i>Posteriorly.</i>	Posterior perforated substance.	Pillars of formx.
Pineal body.	Tegmenta of cerebral peduncles	Interventricular foramen.
Posterior commissure.		Anterior commissure.
Aqueduct of mid-brain.		

Commissures : The *anterior commissure* is described on p. 223.

The *posterior commissure* is a commissural layer of white fibres connecting the two superior colliculi posteriorly. It forms the posterior boundary of the 3rd ventricle, being placed just above the upper opening of the aqueduct of the mid-brain, and beneath the pineal body.

The connexus interthalamicus: A delicate band of grey matter passing between the thalami, near middle of ventricle. A secondary adhesion, not commissural.

The thalami : Two oblong masses of grey matter, covered with a thin layer of white fibres, the *stratum zonale*, and projecting above into the lateral ventricles. Each has upper and lower, and medial and lateral surfaces, and anterior and posterior extremities.

Upper surface: The lateral part of this projects into the body of the lateral ventricle; the medial part is covered by the fornix and the tela chorioidea. It is separated from the *medial* surface, which bounds the 3rd ventricle, by the stalk of the pineal body, and is separated laterally from the caudate nucleus by the *stria semicircularis*; between the stalk of the pineal and the pulvinar is a triangular depressed surface, the *trigonum habenulae*.

Posterior extremity is formed chiefly by the pulvinar. Below and lateral to this is the eminence of the *lateral*

geniculate body; and just below this is the *medial geniculate body*, the brachium from the superior colliculus passing between them.

Under surface: Placed on the tegmentum of the cerebral peduncle and receives the ascending fibres therein.

Lateral surface: Fibres of the internal capsule pass down between this surface and the lentiform nucleus.

Medial surface: Forms lateral wall of 3rd ventricle, and is covered by ependyma.

Anterior extremity (anterior tubercle): Posterior boundary of interventricular foramen.

The **pineal body** is a cone-shaped body placed at the back of the 3rd ventricle, and overlying the superior quadrigeminal bodies.

NOTE.—The pineal is often calcified after middle age and then forms a useful landmark in cranial radiograms.

The **posterior perforated substance** is a depression containing grey matter placed in the floor of the third ventricle, in the angle of divergence of the peduncles. It is bounded by the mamillary bodies in front, and by the pons behind. It is perforated for bloodvessels to the thalami.

The **mamillary bodies** are two small whitish bodies placed in front of the posterior perforated substance and behind the tuber cinereum. They form a cell station in the path of fibres of the fornix passing from the hippocampus to the anterior nucleus of the thalamus.

The **tuber cinereum** is an eminence of grey matter, situated in front of the mamillary bodies and extending forwards to the optic tract. From its centre a tubular conical process of grey matter, the *infundibulum*, passes downwards and forwards to the posterior lobe of the hypophysis.

The **hypophysis cerebri** (pituitary body) is a reddish-grey vascular mass lying in the sella turcica. It consists of two lobes, the anterior being the larger.

The **optic chiasma** is the union of the two optic tracts, and is placed in the middle line just in front of the tuber cinereum. From the anterior part the two optic nerves proceed.

Decussation of the optic nerves: Optic nerve fibres, from the medial half of each retina decussate in the chiasma; those from the lateral half remain uncrossed. Each side of the brain thus receives impulses from the lateral half of the eye of its own side and the medial half of the opposite eye—*i.e.* impulses from the *field of vision of the opposite side*.

The **lamina terminalis** is a layer of grey matter lying above the optic chiasma, and passing from the extremity of the corpus callosum backwards to the tuber cinereum; laterally it is connected with the grey matter of the *anterior perforated substance*, which lies under the anterior end of the corpus callosum and is pierced by vessels, and with the paraterminal gyrus.

The **anterior commissure** is a bundle of white fibres lying in the anterior part of the 3rd ventricle, in front of the anterior columns of the fornix. The fibres go through the caudate nucleus, and, passing under the lentiform nucleus, ultimately enter the olfactory cortex at the insula.

THE CEREBRAL HEMISPHERES

The **cerebral hemispheres** form as a whole an oval mass, separated into two equal portions by the great longitudinal fissure. Each hemisphere presents three surfaces:

1. **Supero-lateral** : Convex, occupying the vault of the cranium. It has a deep cleft, the *lateral cerebral sulcus*, between the portions occupying the anterior and middle fossæ.
2. **Medial** : Flat; forming one side of the longitudinal fissure.
3. **Inferior** : Irregular, corresponding in shape to the anterior and middle fossæ, and to the upper surface of the tentorium.

The surface of each hemisphere consists of grey matter, and is divided into convolutions or gyri by intervening sulci.

The **longitudinal fissure** separates incompletely the two hemispheres, dividing them completely in front and behind; but at the base near the middle they are

united by the corpus callosum. The falx cerebri occupies the fissure.

The **transverse fissure of the cerebrum** is an infolding of the cortex of the brain, which is seen when the tela choroidea and choroid plexuses of the lateral ventricles are removed. It extends from the tip of the inferior horn of the lateral ventricle on one side, over the thalamus and 3rd ventricle to the tip of the inferior horn on the other side.

The **choroid fissure** is C-shaped, extending from tip of inferior horn around the thalamus to the inter-ventricular foramen. It accommodates choroid plexus of lateral ventricle. The two choroid fissures together constitute the transverse fissure of the cerebrum.

The Interlobar Sulci

1. The **lateral cerebral sulcus** commences below at the lateral side of the anterior perforated substance, passes upwards and outwards between the frontal and temporal lobes, and divides into three branches: *anterior*, *ascending*, both passing into the frontal lobe, and *posterior* or *horizontal*, passing upwards and backwards to about the middle of the supero-lateral surface of the hemisphere, separating parietal and temporal lobes. On separating the gyri bounding this sulcus the *insula* is exposed.

2. The **central sulcus** commences at the longitudinal fissure near the vertex, passes downwards and forwards nearly as far as the division of the lateral cerebral sulcus. It separates the parietal and frontal lobes.

3. The **parieto-occipital sulcus** occupies two surfaces of the brain, a *medial* or *perpendicular* fissure, seen on the medial surface of the hemisphere, and a *lateral*, extending on the lateral surface, between the parietal and occipital lobes, for about an inch.

4. The **calcarine sulcus** (see p. 228).

5. The **sulcus cinguli** commences in front near the anterior perforated substance, and takes a course on the medial surface of the hemisphere about midway between the corpus callosum and the edge of the

hemisphere, ending a little behind the upper end of the central sulcus.

6. The **collateral sulcus** lies along the lower border of the hippocampal gyrus; it projects inwards and forms the *collateral eminence* in the inferior horn of the lateral ventricle.

7. **Circular sulcus**, round the insula (see p. 229).

THE LOBES

The hemispheres are by the above sulci arbitrarily divided into six lobes, viz.:

1. **Frontal**: Limited below by the lateral cerebral sulcus, behind by the central sulcus, medially by sulcus cinguli.

2. **Parietal**: Limited in front by the central sulcus, and behind by the parieto-occipital sulcus; below by lateral sulcus continued backwards, and medially by sulcus cinguli.

3. **Occipital**: Bounded in front by the parieto-occipital sulcus; forms the posterior part of the hemisphere.

4. **Temporal**: Occupies middle fossa at the base of the skull, being placed behind the lateral sulcus, and below the parietal and occipital lobes, medially separated from hippocampal gyrus by collateral sulcus.

5. **Insula**: Contained in the lateral cerebral sulcus; triangular in shape.

6. **Rhinencephalon**: Consists of the *olfactory bulb and tract*, the *hippocampal formation* and the *fornix*, bounded above and in front by the *sulcus cinguli*, and below by calcarine and collateral sulci.

NOTE.—*The student is warned against attempting to memorize the names of all except the most important gyri and sulci; the following accounts are for reference only.*

1. The frontal lobe :

Convolutions and sulci :

On inferior surface :

The *orbital sulcus* (H-shaped) divides this surface into medial, lateral, anterior, and posterior orbital convolutions. On the medial

convolution is the olfactory sulcus, which contains the *olfactory bulb*. Medial to this is the gyrus rectus.

On supero-lateral surface :

The *precentral gyrus* is bounded behind by the central sulcus, round the lower end of which it joins the postcentral gyrus; in front by the precentral sulcus.

The *longitudinal frontal gyri* are three in number, *superior*, *middle*, and *inferior*; they occupy the rest of the supero-lateral surface and are separated from each other by two sulci, and from the precentral gyrus by the precentral sulcus.

The inferior frontal gyrus is cut up by branches of lateral sulcus into *pars orbitalis*, *pars triangularis*, and *pars basilaris*, continuous behind with the postcentral gyrus.

On medial surface :

The *medial frontal gyrus* extends along the edge of the longitudinal fissure. It commences at the anterior perforated substance, and is limited below by the sulcus cinguli, and behind by a short vertical sulcus which separates it from the *paracentral lobule*, bounded behind by the upturned end of the *sulcus cinguli*. Below this the *gyrus cinguli* extends down to the callosal sulcus, forming the lower part of the medial surface of the frontal and parietal lobes.

2. The parietal lobe :

Gyri and sulci :

On supero-lateral surface :

The *intraparietal sulcus* commences near posterior limb of lateral sulcus, passes upwards parallel to the lower half of the central sulcus as *inferior postcentral sulcus*, and then turns backwards to end near parieto-occipital sulcus.

The *superior postcentral sulcus* continues the line of the vertical part of the intraparietal sulcus.

The postcentral gyrus is bounded in front by the central sulcus, behind by the postcentral sulcus, below by the lateral sulcus, and above it joins the superior parietal lobule.

The *superior parietal lobule* is bounded by the postcentral sulcus in front, behind by the parieto-occipital sulcus, round which it is connected to the superior occipital gyrus by the *arcus parieto-occipitalis*.

Inferior parietal lobule subdivides into:

The *anterior part*, bounded in front and above by the intraparietal sulcus, round the lower end of which it joins the postcentral gyrus; behind by the posterior limb of the lateral sulcus, round which it joins the superior temporal gyrus.

The *middle part* occupies the centre of the supero-lateral surface of the parietal lobe. Above is the superior parietal lobule, below the temporal lobe, in front the anterior part, and behind the occipital lobe; it arches over the upturned end of the superior temporal sulcus, and is continuous with the middle temporal gyrus.

The *posterior part* curves over the upturned middle temporal sulcus, and is continued into the inferior temporal gyrus.

On medial surface :

The *precuneus* lies anterior to the cuneus; it is bounded behind by the parieto-occipital sulcus, and in front by the ascending terminal limb of the sulcus cinguli.

The *inferior surface* of parietal lobe bounds lateral sulcus above, and with part of frontal lobe forms fronto-parietal operculum.

3. The occipital lobe :

On supero-lateral surface three gyri, *superior*, *middle*, and *inferior*; two sulci—transverse and lateral occipital sulci.

The *superior occipital gyrus* is connected anteriorly

- to the superior parietal lobule by the arcus parieto-occipitalis.

The *middle occipital gyrus* is continuous above with the middle part of inferior parietal lobule, and in front with the middle temporal gyrus.

The *inferior occipital gyrus* is connected in front with the inferior temporal gyrus.

- *On medial surface :*

The *cuneus* is the area between the parieto-occipital and the calcarine sulci.

The *calcarine sulcus* commences at the posterior part of the medial surface of the occipital lobe by a forked extremity; is joined about half-way by the parieto-occipital sulcus, and ends near the posterior extremity of the corpus callosum. Below this is the lingual gyrus continuous in front with the hippocampal gyrus.

On under surface :

The *medial and lateral occipito-temporal gyri* extend from the apex of the temporal lobe to the posterior part of the hemisphere, forming the under surface of both temporal and occipital lobes. Above the medial gyrus is separated by the *collateral sulcus* from the lower part of the lingual gyrus which completes this surface.

4. The temporal lobe :

The superior surface lies in contact with the insula forming the temporal operculum; on it are seen the *transverse temporal gyri*.

On supero-lateral surface :

The *superior temporal sulcus* runs parallel to posterior limb of the lateral sulcus.

- The *middle temporal sulcus* lies parallel to the superior.

The *superior temporal gyrus* is bounded above by posterior limb of lateral cerebral sulcus, and is continuous behind with anterior part of the inferior parietal lobule.

The *middle-temporal gyrus* above joins the middle part of the inferior parietal lobule, and behind merges into the middle occipital gyrus.

The *inferior temporal gyrus* joins the inferior occipital gyrus behind.

On under surface :—

The *occipito-temporal gyri* are described under the occipital lobe (see p. 228)

5. The **insula** is a submerged triangular area of cortex only exposed by separating the gyri bounding the lateral sulcus. These gyri form the *opercula*—viz., orbital (pars orbitalis), frontal (pars triangularis), fronto-parietal (pars basilaris of frontal lobe, and inferior surface of parietal lobe), temporal formed by upper surface of temporal lobe. The island is limited anteriorly, superiorly, and postero-inferiorly from the overlying gyri by the *circular sulcus*, but antero-inferiorly at the *limen insulae* its gyri are in continuity with the anterior perforated substance. The *sulcus centralis* running upwards and backwards from the limen separates the *precentral* from the *postcentral* lobe; the former is subdivided into three gyri breves and the latter into two gyri longi.

6. The **rhinencephalon** : This includes those parts of the brain concerned in reception and conduction of olfactory sensations. The constituent parts are: (1) The olfactory lobe. (2) The hippocampal formation; this comprises the longitudinal striæ of the corpus callosum, the dentate gyrus and the hippocampus. (3) The fornix (see p. 233).

The *olfactory lobe* begins at the anterior perforated substance as the *olfactory tract*, and ends anteriorly in an enlargement, the *olfactory bulb*. It lies in the olfactory sulcus on the orbital surface of the frontal lobe. Posteriorly the tract bifurcates, the lateral root passing across commencement of lateral sulcus to the uncus of the hippocampal gyrus, and the medial one to the longitudinal fissure to join the medial and lateral longitudinal striæ.

The *indusium guseum*, a thin sheet of grey matter lying on upper surface of corpus callosum; continuous round bottom of callosal sulcus with gyrus cinguli. It commences near the anterior perforated substance, as a continuation of the

medial root of the olfactory tract, follows the curves of the corpus callosum, near the posterior end of which it becomes continuous with the dentate gyrus.

The *dentate gyrus* lies in the dentate fissure. It is formed by the superficial grey matter of the hemisphere, which here ends in a fringed margin.

The *hippocampal gyrus* commences below the splenium of the corpus callosum; here the end of the calcarine sulcus cuts into it, leaving a narrow *isthmus* connecting it with the supracallosal gyrus. It runs forwards above the collateral fissure, which separates it from the inferior surface of the temporal lobe and ends as the *uncus*.

The *hippocampal sulcus* lies along the upper border of the hippocampal gyrus, and projects into the inferior horn of the lateral ventricle, forming the hippocampus.

"

THE INTERIOR OF THE CEREBRUM

The **corpus callosum** lies at the bottom of the longitudinal fissure. It is the great transverse commissure of the hemispheres, and consists principally of transverse fibres.

Length : About 4 inches, extending to within $1\frac{1}{2}$ inches of the anterior, and $2\frac{1}{2}$ inches of the posterior extremities of the hemispheres.

Shape : Broader behind than in front, thicker at each end than at the middle, and thickest behind. It terminates posteriorly in a free, thickened border, the *splenium*; in front it curves down towards the base of the brain, the bend being known as the *genu*, and the reflected part as the *rostrum*.

On either side the fibres of the corpus callosum radiate into the hemisphere (*radiation of the corpus callosum*). Those passing forwards into the frontal lobe are called the *forceps minor*, those from the splenium into the occipital lobe form the *forceps major*, and intermediate fibres are known as the *tapetum*.

Its upper surface is convex and covered by the

indusium griseum, on which can be defined delicate ridges, the *striae longitudinales mediales*, and on either side the *striae longitudinales laterales*.

Relations. Upper surface forms floor of longitudinal fissure; under surface connected behind with the fornix, and in front of this with the *septum lucidum*. The extremity of the rostrum is connected centrally with the *lamina terminalis*, and laterally with two white bands, the *peduncles of the corpus callosum* (*subcallosal gyrus*), which pass backwards and laterally over the anterior perforated substance towards the lateral sulcus to the anterior extremity of the temporal lobe. Traced upwards, these fibres are continuous with the *striae longitudinales*. The corpus callosum roofs in the bodies and anterior horns of the lateral ventricles.

The **lateral ventricles** are two in number, one in each hemisphere. They communicate below and in front with the third ventricle by the interventricular foramen. Each ventricle consists of a central part (*body*), and three horns—*anterior*, *posterior*, and *inferior*. (Figs. 51, 52).

Relations of the body :

Roof : Tapetum of corpus callosum.

Medial wall : Septum lucidum and the fornix.

Floor : From before backwards :

1. Caudate nucleus of corpus striatum.
2. Stria semicircularis.
3. Part of thalamus in front of choroid plexus.
4. Choroid plexus of lateral ventricle.
5. Fimbriated edge of the fornix.

The **anterior horn** is the anterior end of the ventricle, which curves laterally, forwards, and downwards over the caudate nucleus. Lies anterior to interventricular foramen. Contains no choroid plexus.

Relations :

<i>Anterior.</i>	<i>Superior.</i>	<i>Inferior and Lateral.</i>	<i>Medial.</i>
Geni of corpus callosum.	Corpus callosum (tapetum).	Caudate nucleus.	Septum lucidum.

The **posterior horn** projects backwards and medially into the occipital lobe. Usually asymmetrical, often absent. Contains no choroid plexus.

Relations :

<i>Superior and Lateral.</i>	<i>Inferior.</i>	<i>Medial.</i>	<i>At Junction of Posterior and In- ferior Horns.</i>
Fibres of corpus callosum (tapetum). Optic radiation.	White substance of occipital lobe.	Calcar avis, formed by the calcarine sulcus projecting inwards.	Collateral eminence formed by the inward projection of the collateral sulcus.

The *inferior horn* passes at first backwards and outwards round the posterior part of the thalamus, then downwards and forwards in temporal lobe.

Relations :

<i>Superior.</i>	<i>Inferior.</i>	<i>Medial</i>	<i>Lateral</i>
Fibres of corpus callosum (tapetum). Amygdaloid nucleus. Tail of caudate nucleus.	Hippocampus. Fimbria. Choroid plexus. Eminentia collateralis	Pia mater. Ependyma.	White substance of the hemisphere.

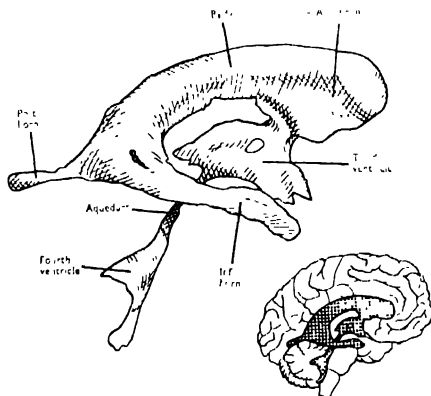


FIG. 51.—THE VENTRICLES OF THE BRAIN VIEWED FROM THE RIGHT.

The **hippocampus**: A large projection of grey matter in the whole length of the floor of the inferior horn of the lateral ventricle. It corresponds with the hippocampal sulcus. The anterior ex-

tremity becomes enlarged and indentated, forming the *pes hippocampi*. Its ventricular surface is covered by a film of white matter, the *alveus*, which continues along the medial border of the hippocampus as the *fimbria*, a narrow white band prolonged into the posterior pillar of the fornix.

The **fornix** consists of two white longitudinal strata beneath the corpus callosum, separated in front and behind, forming the columns, but joined in the middle, forming the body.

The *body* is triangular in shape, the base being placed posteriorly, and here connected with the corpus callosum. In front of this it is connected with the septum lucidum along its upper surface. The lateral margins are free, lying above the choroid plexus of the lateral ventricles. The under surface lies upon the tela chorioidea of 3rd ventricle.

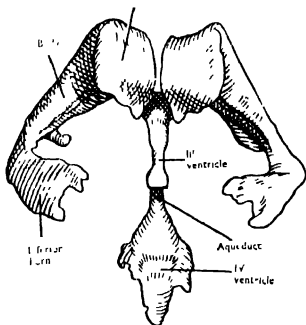


FIG. 52.—THE VENTRICLES OF THE BRAIN VIEWED FROM IN FRONT.

The *anterior columns* pass downwards, forming the anterior boundary of the interventricular foramen, then through the grey matter on the lateral side of the 3rd ventricle; on reaching the base of the brain they make a half figure-of-eight turn, forming the white envelope of the mammillary bodies; they then relay

and pass into the anterior nucleus of the thalamus. The pillars receive near the interventricular foramen the fibres of the peduncles of the pineal body, and those of the stria semicircularis.

The *posterior columns* : The fimbria of each side is prolonged upwards along medial ependymal wall of inferior horn. Curving around pulvinar it becomes posterior pillar of fornix, attached to splenium of corpus callosum and converging with its fellow to the mid-line and body of fornix. Most fibres proceed through body to anterior pillar of fornix, but a few cross mid-line, the *hippocampal commissure*, to reach opposite mamillary body.

The **interventricular foramen** is the interval between the anterior columns of the fornix and the thalami. It is the communication between third and lateral ventricles.

The **septum lucidum** is a double vertical partition between the lateral ventricles, attached to the fornix and rostrum below, and to the under surface of the body of the corpus callosum above. Between the layers is the cavity of septum lucidum, a closed narrow space, having no connection with the other ventricles, and not lined by ependyma.

The **tela chorioidea** of the 3rd ventricle is a triangular double fold of pia mater prolonged through the transverse (choroid) fissure and lying over the 3rd ventricle and upper surfaces of the thalami. Its apex reaches the interventricular foramen, and the fornix lies upon its upper surface. Between its layers are the—

1. Choroid plexuses :

Of the lateral ventricles : Fringed vascular processes extending from the interventricular foramen to commencement of inferior horn, and attached along the lateral margins of the tela chorioidea of this ventricle; thence each passes into the inferior horn, resting on the fimbria and hippocampus, forming the *choroid plexus of the inferior horn*. Supplied by anterior choroidal artery from internal carotid, reinforced by posterior choroidal branches from posterior cerebral (vertebral system of arteries).

Of the 3rd ventricle : From the under surface of the tela chorioidea there depend two vascular fringes, diverging behind, and forming the choroid plexuses of 3rd ventricle.

2. **Internal cerebral veins** : Two veins formed by junction of the thalamo-striate vein, veins of septum lucidum and choroid vein of each side; running backwards between the layers of the tela chorioidea, they unite posteriorly into one trunk, the great cerebral vein, which opens into the straight sinus.

THE BASAL GANGLIA

Subcortical masses of grey matter in the hemispheres form the **corpora striata**, so called from their appearance on section, which displays alternate white and grey bands; they are two in number, one in each hemisphere. Each consists of an ovoid mass of grey matter lying lateral to and in front of the thalamus. The largest part (*lentiform nucleus*) lies in the white matter of the hemisphere outside the lateral ventricle, and a smaller part (*caudate nucleus*) appears in the floor of that space.

The *caudate nucleus* is comma-shaped, with the larger end placed anteriorly, occupying the floor and lateral wall of the anterior horn; the narrow posterior part lying along the floor and lateral wall of the lateral ventricle makes a C-shaped curve into the roof of the inferior horn, where it is joined by the stria semicircularis to join the *amygdaloid nucleus* in the roof of the tip of the inferior horn.

The *lentiform nucleus* lies lateral to and at a lower level than the caudate nucleus, from which it is separated by a layer of white fibres, the *internal capsule*. It consists of a small medial part that is pale, the *globus pallidus*, and a larger lateral part called the *putamen*. Lateral to the nucleus is another stratum of white fibres, the *external capsule*, and beyond this a thin lamina of grey matter called the *claustrum*, the lateral surface of which lies next to the white substance of the insula.

The **thalami** (see p. 221)

The **stria semicircularis** is a narrow band of white fibres attached to the anterior column of the fornix in front, whence it passes backwards in the floor of the lateral ventricle, between the caudate nucleus and the thalamus; it then passes into the roof of the inferior horn, at the end of which it enters a mass of grey matter, the **amygdaloid nucleus**, continuous with the superficial grey matter at the anterior perforated substance.

SYNOPSIS OF THE WHITE FIBRES OF THE CEREBRUM

The white medullated fibres of the cerebrum may be divided according to their course and connections into:

1. Commissural fibres.
2. Association fibres.
3. Projection fibres.

Commissural fibres connect corresponding areas in the two cerebral hemispheres, and constitute:

- (a) Corpus callosum.
- (b) Anterior commissure.
- (c) Hippocampal commissure (p. 234).
- (d) Posterior commissure.

Association fibres connect gyri adjacent or more widely separated as the case may be, and are divided into short and long. They are all homolateral; examples of the long association fibres are the cingulum, the uncinatæ bundle, the superior and inferior longitudinal bundles.

Projection fibres connect the cerebral cortex with the lower parts of the brain and the spinal medulla. The projection fibres of the more primitive parts of the brain (archæpallium) form two tracts, the fornix and the stria semicircularis. The projection fibres of the cortex converge on the corpus striatum and form the corona radiata, which is continuous with the internal capsule.

The anterior limb of the internal capsule contains:

1. Fronto-pontine fibres.
2. Thalamo-cortical fibres.

The genu and posterior limb contain:

1. The motor pathway (cortico-spinal fibres).
2. Thalamo-cortical fibres (ordinary sensory pathway).
3. Temporo-pontine fibres.
4. Fibres of the auditory radiation.
5. Fibres of the optic radiation.
6. Cortico-thalamic fibres.

THE MEMBRANES OF THE BRAIN, OR MENINGES

The **DURA MATER**, the most external, is a dense fibrous membrane, which is closely attached to the bones of the skull, forming their internal periosteum. The inner surface is smooth, and covered with mesothelium. It is continuous with the dura mater of the spinal cord through the foramen magnum. The fibrous part of the dura mater is divided into two layers: an outer, forming the periosteum, and an inner, lying outside the mesothelium, forming certain processes, and which, by its separation in certain situations, forms the *sinuses* (for sinuses of dura mater, see p. 180). On the upper surface, near, and projecting into the superior sagittal sinus, are the *arachnoid granulations*, which are enlarged villi of the arachnoid projecting through the layers of dura mater.

Processes of the dura mater:

The **falx cerebri**: Placed vertically between the two hemispheres of the cerebrum, attached in front to the crista galli, behind to the upper surface of the tentorium, and between these, above to middle line of internal surface of skull, while the lower border is concave and free. Between its layers are the superior and inferior sagittal and the straight sinuses.

The **tentorium cerebelli** is a crescentic fold of dura mater placed between the cerebrum and the cerebellum. It has an outer convex border, by which it is attached in front to the posterior clinoid processes,

superior edge of the petrous bone, and behind to the margins of the groove for the transverse sinus. The inner concave border is free posteriorly, and forms the opening through which the cerebral peduncles and the posterior cerebral arteries pass from the posterior into the middle cranial fossa; in front this border passes over the attached border, and is attached to the anterior clinoid processes. The tentorium is suspended from falx cerebri; it is highest in front, and from this point descends on all sides. Between its layers are the transverse, superior petrosal, and straight sinuses.

The **falx cerebelli** reaches vertically from the tentorium to the foramen magnum, separating the two hemispheres of the cerebellum. It is attached posteriorly to the internal occipital crest, where it encloses the occipital sinus, and below to each side of the foramen magnum.

The **PIA MATER** consists of a fibrous membrane supporting blood vessels, and closely invests the brain, dipping into the sulci. At the transverse fissure it is prolonged into the lateral ventricles and over the 3rd ventricle, pushing the ependymal lining of those cavities in front of it, and forming the tela chorioidea carrying the choroid plexuses of the lateral and 3rd ventricles. It is prolonged over the roof of the 4th ventricle, sending inwards two vascular fringes, the choroid plexuses of that cavity.

The **ARACHNOID MATER** is a thin membrane lying outside the pia mater, but is not so closely applied to the brain, as it lies surface to surface in contact with dura. Between the pia mater and the arachnoid is the *subarachnoid space*, containing the cerebrospinal fluid. The space between the dura mater and arachnoid is known as the *subdural space*, a potential space only, containing a film of tissue fluid (lymph), which does not communicate with the cerebrospinal fluid.

The **subarachnoid space** is larger in some places than in others. The arachnoid stretches across between the two temporal lobes at the base of the brain, forming the *interpeduncular cistern*, which lies

anterior to the pons and reaches as far forward as the optic nerves. Beneath the cerebellum it forms in a like manner the *cerebello-medullary cisterna*, by stretching between the under surface of the cerebellum and the posterior surface of the medulla; this cistern can be tapped by passing a needle through posterior atlanto-occipital membrane and spinal dura mater.

At the bottom of the longitudinal fissure the sub-arachnoid space is also large

The subarachnoid space communicates with the cerebral ventricles by the *median aperture* of 4th ventricle, an opening into the 4th ventricle in the expansion of pia mater across the roof. There are two other *lateral apertures* in the pia mater, placed on each side of the upper roots of the glosso-pharyngeal nerve, under the flocculus.

SUMMARY OF THE VENTRICULAR SYSTEM (Figs. 51, 52)

Each cerebral hemisphere has a lateral ventricle with choroid plexus. The 3rd ventricle of the mid-brain receives fluid through the interventricular foramina from the lateral ventricles; the 3rd also has its own choroid plexus. The 3rd ventricle, aqueduct, 4th ventricle and central canal of the spinal cord are in continuity; the 4th ventricle has its own choroid plexus. Cerebro-spinal fluid can leave this system only by the foramina in the roof of the 4th ventricle; it passes thus into the subarachnoid space, from which it is eventually absorbed into the venous system via arachnoid villi and granulations.

The Nerves

THE CRANIAL NERVES

OLFACTORY—Course: The olfactory tract passes forwards in the olfactory sulcus on the under surface of the frontal lobe, resting on cribriform plate and expanding anteriorly into olfactory bulb. There is an enlargement at the posterior part of the upper surface called the *olfactory tubercle*.

Distribution: Nerve filaments (non-medullated) arise from nerve-cells in the nasal mucosa (p. 353), and pass upwards through foramina in the cribriform plate of the ethmoid to reach the olfactory bulb; they are divided into three sets to supply mucous membrane of the olfactory area of the nose. This comprises superior nasal concha (lateral branches), corresponding part of septum (medial branches), and roof (intermediate branches).

Special function: Nerve of smell.

OPTIC—Origin: From ganglion cells in retina. Fibres pass through lamina cribrosa of sclera to form optic nerve. This passes backwards and upwards and slightly medialwards to the optic foramen. Its fibres are *medullated, but have no neurilemma*. Optic nerve is really a projection of white matter of cerebrum. It is surrounded, right up to the eyeball, by dura, arachnoid and pia mater, with cerebro-spinal fluid, in continuity with the cerebral subarachnoid space. In the cranium the two nerves partially decussate to form the optic chiasma (see p. 222), from which the optic tracts are continued back to the lateral geniculate body and superior corpus quadrigeminum.

Special function : Nerve of sight and of light reflexes.

OCULO-MOTOR—*Superficial origin* : Medial side of cerebral peduncle just in front of pons. *Deep Origin* : Floor of aqueduct of mid-brain. Parasympathetic cell bodies (Edinger-Westphal) at cranial end of main nucleus.

Course : Pierces dura mater of roof of cavernous sinus to enter canal in lateral wall of cavernous sinus, lying above and medial to trochlear nerve. As it passes forwards to enter orbit through superior orbital fissure, the trochlear nerve and frontal branch of trigeminal cross laterally and become superior to it. It divides in the fissure into two branches which enter orbit between the heads of the lateral rectus, the naso-ciliary branch of the trigeminal lying between the two; whilst in cavernous sinus it communicates with cavernous plexus.

Distribution : Superior branch supplies superior rectus and levator palpebræ superioris. Inferior divides into three, for medial rectus, for inferior rectus, and for inferior oblique, which latter gives off short or motor root to the ciliary ganglion, through which the oculo-motor nerve supplies the ciliary muscle and the sphincter pupillæ.

Special function : Motor nerve of some muscles of eyeball, of ciliary muscle and sphincter fibres of iris.

TROCHLEAR—*Origin*—*Superficial* : Superior medullary velum, just below inferior colliculi. *Deep* : Floor of aqueduct of mid-brain. Fibres decussate on dorsal aspect of aqueduct, between deep and superficial origins.

Course : Winds round lateral surface of cerebral peduncle and pierces roof of cavernous sinus; passes forwards in lateral wall of cavernous sinus below oculo-motor, but enters orbit through superior orbital fissure lateral to the tendinous ring.

Distribution : Enters orbital surface of superior oblique.

Special function : Motor nerve of superior oblique.

TRIGEMINAL—*Origin*—*Superficial* : From the side

of the pons, by small motor and large sensory roots, the latter having a ganglion on it. *Deep* : **Afferent fibres** end in (a) sensory nucleus in floor of 4th ventricle (pons); (b) (spinal tract), posterior horn of grey matter of medulla, and upper part of cord; (c) (mesencephalic tract), side of aqueduct of the mid-brain. **Motor** : Floor of 4th ventricle (pons).

Course : The two roots pass forwards below tentorium through oval opening in dura mater near apex of petrous bone. Dura prolonged over roots between fibrous and endosteal layers of middle cranial fossa, forming *cavum trigeminale*. Roots pass on, the sensory root entering the trigeminal ganglion, lodged on the apex of petrous part of temporal bone. The motor root passes under ganglion and is not connected with it, but goes to foramen ovale, where it unites with the mandibular division.

The **trigeminal ganglion** : Lodged in a depression near the apex of petrous part of temporal, gives off from its anterior edge the *ophthalmic*, *maxillary*, and *mandibular* divisions. The two former are purely sensory; the last by receiving small motor root becomes a mixed nerve.

The **OPHTHALMIC NERVE** (sensory and smallest branch): Courses along lateral wall of cavernous sinus below oculo-motor and trochlear nerves, to enter orbit through superior orbital fissure. In sinus communicates with cavernous plexus and oculo-motor, trochlear, and abducent nerves, and divides into three branches, two of which, frontal and lacrimal, enter orbit above lateral rectus, whilst the third or naso-ciliary passes between two heads of origin of that muscle, and between two divisions of oculo-motor nerve.

Branches

Lacrimal : Passes along lateral wall of orbit to under surface of lacrimal gland, communicates with zygomatic of maxillary (receiving parasympathetic secreto-motor fibres from the spheno-palatine ganglion for lacrimal gland), finally pierces orbital fascia, and supplies skin of upper eyelid, communicating with branches of facial.

Frontal : Largest branch, enters orbit just lateral to trochlear nerve, passes forward on levator palpebræ, and divides into:

Supratrochlear : Directed forwards and medially between trochlea and supra-orbital notch; distributed to skin of forehead and communicates with infratrochlear.

Supra-orbital : Continuation of frontal, passes through notch, supplies palpebral filaments, and ends on forehead by dividing just outside orbit into two branches, of which the lateral is the larger. It supplies the anterior half of the scalp. Communicates with facial.

Naso-ciliary : Enters orbit between the heads of the lateral rectus, passes forwards and medially over optic nerve along medial side of orbit. Continues as *anterior ethmoidal* nerve through anterior ethmoidal foramen; re-entering cranium, it passes down nasal slit by the side of the crista galli, dividing into two terminal branches—viz:

Medial : Supplying mucous membrane of the adjacent part of the septum.

Lateral : Runs along groove on internal surface of nasal bone, supplies lateral wall of nose then passes between bone and lateral cartilage to supply skin of ala and tip of nose (*external nasal nerve*). Communicates with facial.

Branches from naso-ciliary in the orbit

Ganglionic : Arises between heads of lateral rectus, passes along lateral side of optic nerve, entering the posterior superior angle of ciliary ganglion, of which it forms the long or sensory "root."

Long ciliary (2 or 3) pass along medial side of optic nerve, join some short ciliary branches from ganglion, and, piercing the sclera, are distributed to ciliary body and iris. They carry sympathetic fibres from cavernous plexus to dilator pupillæ; cell bodies in superior cervical ganglion.

Posterior ethmoidal : Enters posterior ethmoidal foramen for posterior ethmoidal and sphenoidal sinuses.

- **Infratrochlear:** Given off as nerve enters anterior ethmoidal foramen; it passes to medial angle of orbit, communicating beneath trochlea with the supratrochlear of frontal. It supplies lacrimal sac, skin of upper lid and root of nose.

The **CILIARY GANGLION** is a small reddish-coloured body, placed between the optic nerve and the lateral rectus, at the back part of the orbit.

Branches of communication or roots :

Long or sensory root : From the naso-ciliary of the ophthalmic, joins posterior superior angle. Cell bodies in trigeminal ganglion. Sensory to eyeball.

Short or parasympathetic (motor) root : From the branch of the oculo-motor nerve supplying inferior oblique, joins postero-inferior angle. Cell bodies in anterior part of third nerve nucleus (Edinger-Westphal nucleus). Relay in the ganglion, whence fibres supply sphincter pupillæ and ciliary muscle.

Sympathetic : From the cavernous plexus, and frequently joined with the long or sensory root. Cell bodies in superior cervical ganglion. Fibres are vasoconstrictor to intrinsic vessels of eyeball.

Branches of distribution :

Short ciliary nerves : Ten or twelve given off in two bundles, large inferior and small superior. Pass forwards above and below optic nerve, with long ciliary of naso-ciliary. The branches subdivide and, piercing the sclera, run in grooves on its internal surface to end in ciliary muscle, iris and cornea.

The **MAXILLARY NERVE** (sensory) passes from the middle of the trigeminal ganglion through foramen rotundum, then across pterygo-palatine fossa to enter the infra-orbital canal, and here receives the name of **infra-orbital**. Emerging on the face from the infra-orbital foramen under the levator labii superioris, it divides into a number of branches, **nasal**, **inferior palpebral** and **superior labial**, and joins with branches of the facial nerve to form the infra-orbital plexus.

Branch in the skull :

Recurrent : Given off near origin, to dura mater.

Branches given off in the pterygo-palatine fossa :

Zygomatic : Enters orbit by inferior orbital fissure and divides into:

Zygomatico-temporal : Passes along lateral wall of orbit, here giving parasympathetic fibres to lacrimal nerve for lacrimal gland; it then goes through a foramen in the zygomatic bone, and becomes cutaneous on the temple.

Zygomatico-facial : Passes to lower and lateral angle of orbit, goes through zygomatic foramen, and becomes cutaneous on the face.

Ganglionic (2): Descend to pterygo-palatine (sphenopalatine) ganglion.

Posterior superior alveolar (dental): Comes off just before nerve enters canal, and divides into.

Lateral branch : Passes downwards to the gums.

Medial branch : Enters a canal in the maxilla, and runs along lateral wall of antrum; supplies the molar teeth and mucous membrane of the antrum. Communicates with middle superior alveolar (when present).

Branches arising within the infra-orbital canal :

Middle and anterior superior alveolar (dental): Descend in canals in anterior wall of antrum, and divide into branches.

The *middle* supplies the bicuspid teeth (not always present).

The *anterior* supplies incisor and canine teeth and anterior part of inferior concha.

Branches arising on the face :

Inferior palpebral : Supplies skin of lower eyelid.

External nasal : To skin of side of nose.

Superior labial : Three or four branches to skin of upper lip and mucous membrane of vestibule, including gum.

The PTERYGO-PALATINE (SPHENO-PALATINE) GANGLION is deeply placed in the pterygo-palatine fossa, near the sphenopalatine foramen.

Roots

Parasympathetic (secreto-motor) : Cell bodies in superior salivatory nucleus, axis cylinders in nervus intermedius, leave at geniculate ganglion as greater

(superficial) petrosal nerve. (It foramen lacerum joined by deep petrosal nerve to form *nerve of pterygoid canal*, which joins the ganglion.) These parasympathetic fibres relay in ganglion; post-ganglionic fibres secreto-motor to lacrimal gland and all glands of nose, palate and paranasal sinuses (ganglion of hay fever—"tears and a running nose").

Sympathetic: Cell bodies in superior cervical ganglion, fibres in carotid plexus, *deep petrosal nerve* in foramen lacerum joins greater (superficial) petrosal. Reach ganglion via nerve of pterygoid canal, pass through ganglion without relay. Vasoconstrictor to mucous membrane of nose, palate, paranasal sinuses.

Sensory: From the maxillary. Cell bodies in trigeminal ganglion.

Branches of distribution

Ascending: Three or four small branches to the periosteum of the orbit.

Descending: The *greater palatine nerve* passes through greater palatine canal to hard palate, there dividing into branches which run forward in grooves in the bone nearly to the incisor teeth. Joining the naso-palatine (long spheno-palatine) nerve in the region of incisive canal, it supplies the gums and mucous membrane of hard palate. Whilst in the greater palatine canal it gives off the *inferior nasal branches*, which supply mucous membrane on middle and inferior nasal conchæ, and branches to maxillary sinus.

The *lesser palatine nerves* are two: one enters palatine canal to supply mucous membrane of soft palate, uvula and tonsil: the other passes through lesser canal to the tonsil and soft palate.

Medial:

Posterior superior nasal (short spheno-palatine): (4 or 5) through spheno-palatine foramen to supply the posterior and upper part of the lateral wall of the nose.

One branch, the *naso-palatine (long spheno-palatine)*, larger and longer than the others, passes inwards through spheno-palatine foramen, crosses roof of nasal

fossa to septum, on which it passes downwards and forwards with its fellow of the opposite side to the median incisive foramina, the left nerve being anterior, and, communicating with the greater palatine nerve, ends in the gums of the incisor teeth. Branches are given to the mucous membrane over the septum.

Posterior :

A *pharyngeal* branch that passes backwards through the palatino-vaginal canal to supply mucous membrane of upper part of naso-pharynx and sphenoidal sinus ostium.

The MANDIBULAR NERVE is the largest of the three divisions of the trigeminal. The large sensory root comes from the inferior angle of the ganglion, and is joined on its deep aspect near or in the foramen ovale by the small motor root which lies under the sensory root. The united nerve leaves the skull by foramen ovale, and immediately breaks up into anterior and posterior divisions.

Branches from the trunk

Recurrent : Passes backwards with the middle meningeal artery, through foramen spinosum, to supply dura mater. Called *nervus spinosus*.

Medial pterygoid : To deep surface of medial pterygoid, connected near origin with otic ganglion.

Branches from the anterior (small and motor except one branch, the buccal) division :

Masseteric : Passes laterally with posterior deep temporal nerve above lateral pterygoid, then over mandibular notch, to deep surface of masseter and gives twigs to mandibular joint.

Deep temporal (3) : *Anterior*, to supply front of temporal muscle; *middle*, passes (when present) with buccal nerve to deep part of temporal muscle; *posterior*, often united with masseteric nerve, to back part of temporal muscle.

Buccal (sensory) : Comes out between heads of lateral pterygoid to reach buccinator, communicates with facial, and is distributed to mucous membrane and skin of cheek.

Lateral pterygoid : To lateral pterygoid (generally given off with buccal).

Branches from the posterior (large and sensory except one branch, the mylo-hyoid) division :

The **auriculo-temporal nerve** comes off by two roots, between which the middle meningeal artery passes; runs backwards under lateral pterygoid muscle, round mandibular capsule, then upwards, with superficial temporal artery, beneath parotid to temporal fossa, where it becomes cutaneous, and lies posterior to superficial temporal artery.

Branches of the auriculo-temporal :

Nerve to external auditory meatus : To ear above meatus.

Branch to tympanic membrane : To skin of tragus, pinna, meatus, and to membrana tympani.

Communicating : To otic ganglion and facial nerve.

Temporal : To scalp with artery, joins temporal branches of facial.

Parotid : To gland, carrying secretomotor fibres from otic ganglion.

Mandibular : To joint.

*The **inferior alveolar (dental) nerve** passes down medial to lateral pterygoid muscle, and posterior to the lingual nerve; then between the ramus of jaw and spheno-mandibular ligament, to the mandibular foramen; in mandibular canal runs at first anterior to and then above the inferior dental artery. It supplies the molar and bicuspid teeth, and emerges at the mental foramen, having just previously divided into two branches, one of which (incisor) is continued in the bone, and the other (mental) is continued over the chin.

Branch before entering the mandibular foramen :

Mylo-hyoid : Descends in a groove on the medial side of ramus of jaw to lower surface of mylo-hyoid muscle, supplying it, and giving a branch to the anterior belly of the digastric.

Branches given off in the dental canal :

Dental : To molars and bicuspid.

Incisor : To canine and incisors.

Mental : Passes out of mental foramen, and divides into branches which supply skin of chin and lower lip, mucosa and gum of vestibule, and communicate with the facial.

The **lingual nerve** lies at first medial to the lateral pterygoid muscle; it then passes downwards in front of the inferior dental nerve, and is joined at an acute angle by the *chorda tympani* from the facial. Thence it passes downwards and forwards between medial pterygoid and ramus of mandible, under the superior constrictor of the pharynx. Thence passes into mouth above posterior edge of mylo-hyoid (grooving mandible at third molar), and runs antero-medially to dip below submandibular duct and lie on surface of hyoglossus muscle above the duct. Is continued to tip of tongue.

Branches

Communicating : With inferior alveolar (dental) at commencement; with facial through chorda tympani; branches are sent also to submandibular ganglion and the hypoglossal nerve.

Distribution : To mucous membrane of sides and tip of tongue, the lingual gums and sublingual gland, the terminal branches supplying anterior ; of mucous membrane of dorsum of tongue

The SUBMANDIBULAR GANGLION lies between the hyoglossus muscle and the deep part of the submandibular gland.

Roots :

Sensory : From the mandibular, via the lingual. Cell bodies in trigeminal ganglion.

Parasympathetic : Cell bodies in superior salivatory nucleus, from which axis cylinders run in nervus intermedius and chorda tympani (p. 252). Relay in ganglion for supply to sublingual gland, for supply of submandibular gland relay in hilum of same.

Sympathetic : From plexus round facial artery. Cell bodies in superior and middle cervical ganglia

Branches

Five or six small twigs supply the submandibular

gland, the mucous membrane, and submandibular duct.

The OTIC GANGLION lies on the medial surface of the mandibular nerve, close to the foramen ovale, and is connected with the commencement of the nerve to the medial pterygoid muscle.

Roots

Parasympathetic : Through lesser (superficial) petrosal nerve (p. 254). Cell bodies in inferior salivatory nucleus, axis cylinders in glosso-pharyngeal nerve, tympanic branch, lesser superficial petrosal nerve. Relay in ganglion.

Sympathetic : From plexus on middle meningeal artery. Cell bodies in superior cervical ganglion.

Sensory : From mandibular. Cell bodies in trigeminal ganglion.

Motor : Not present in other cranial ganglia. From mandibular. Cell bodies in motor nucleus of 5th nerve in pons. For innervation of the two tensor muscles (tensor palati and tensor tympani).

Branches

Communicating : To auriculo-temporal (secretomotor to parotid gland) and to chorda tympani (aberrant taste fibres).

Muscular : To the tensor tympani and tensor palati.

THE ABDUCENT NERVE—*Origin*—*Superficial* : From the sulcus between the pons and medulla, anterior to the pyramid. *Deep* : Floor of 4th ventricle beneath facial colliculus.

Course : Pierces dura mater on clivus and grooves tip of petrous bone to reach cavernous sinus; lies lateral to internal carotid, and below the other nerves. Enters orbit by superior orbital fissure, between the heads of the lateral rectus, lying above ophthalmic vein.

Distribution : Lateral rectus (ocular surface).

Relations : The following table shows how the nerves of the orbit change their relative position to one another. They lie from above downwards:

In the Cavernous Sinus.

Oculo-motor. Trochlear. Trigeminal. Abducent.

In the Superior Orbital Fissure.

Trochlear. Frontal. Lacrimal.

(Above the muscles from medial to lateral.)

Superior division of	}	Enter between the heads of lateral rectus.
oculo-motor		
Naso-ciliary branch of ophthalmic		
Inferior division of		
oculo-motor		
Abducent		

THE FACIAL—*Origin*—*Superficial*: From between the pons and olive. *Deep*: Floor of 4th ventricle anterior and lateral to nucleus of abducent nerve.

Sensory root: Better called nervus intermedius (see p. 253).

Course: Both roots pass forwards and laterally to enter the internal auditory meatus, and at the bottom of the meatus join together. The nerve then enters the canal for facial nerve, runs first forwards and laterally above and between cochlea and vestibule; then backwards in medial wall of tympanum, just above fenestra vestibuli, presenting at the bend a swelling, the *geniculate ganglion*; and finally it passes downwards, to emerge from the bone at the stylo-mastoid foramen; it then passes laterally and forwards in the parotid, dividing behind ramus of mandible into branches, which further subdivide and intercommunicate, forming the parotid plexus.

Branches within the canal

Greater (superficial) petrosal passes from ganglion of facial nerve through hiatus on anterior surface of petrous, then through foramen lacerum, where it joins the deep petrosal to form the nerve of the pterygoid canal (see p. 246). Contains only nervus intermedius fibres.

Communicating with the lesser (superficial) petrosal nerve.

External petrosal: From ganglion of facial nerve to plexus on middle meningeal artery (rare—existence doubtful).

c **Nerve to stapedius:** Passes forwards into muscle.

Chorda tympani: Given off just before exit from stylo-mastoid foramen, ascends to tympanum through posterior canaliculus for chorda tympani; it then courses between membrana tympani and the base of pyramid, and between handle of malleus and long process of incus; it leaves tympanum by anterior canaliculus for chorda tympani, and, passing through canal for chorda tympani, emerges at the medial end of the petro-tympanic fissure, grooves spine of sphenoid, then forwards between two pterygoids to join lingual nerve. It supplies the mucous membrane of the anterior $\frac{1}{2}$ of the tongue with taste fibres, and the submaxillary, sublingual and some buccal glands with secreto-motor fibres.

Communicating with the auricular branch of the vagus.

Branches given off at exit from stylo-mastoid foramen:

Posterior auricular: Passes up behind and between mastoid process and meatus, dividing into *auricular* to supply auricularis posterior, and *occipital* to posterior belly of occipito-frontalis.

Stylo-hyoid: To muscle.

Digastric: Given off with former to supply posterior belly of digastric.

Branches on the face

Divides in parotid, where branches form parotid plexus.

Temporal: Supply anterior and superior auriculares, joining zygomatico-temporal of maxillary and auriculo-temporal of mandibular; anterior branches supply orbicularis oculi, frontal belly of occipito-frontalis and corrugator, joining lacrimal and supra-orbital nerves.

Zygomatic: To supply muscles of eyelid, and join supra-orbital.

Buccal: To buccinator and orbicularis oris; joins buccal of mandibular. Deep branches pass under zygomaticus and form an infra-orbital plexus for supply of muscles of upper lip and nose.

Mandibular: To muscles of lower lip and chin; joins mental branch of inferior dental. Commonly descends below angle of mandible and crosses inferior border of jaw on facial artery.

Cervical: Perforates cervical fascia beneath mandible, to supply platysma, and join transverse cervical.

NERVUS INTERMEDIUS—Incorrectly known as sensory root of facial nerve. Really a separate cranial nerve overlooked by ancients who counted only twelve pairs. *Origin*—*Superficial*: Between 7th and 8th nerves. *Deep*: Secretomotor (para-sympathetic) from superior salivatory nucleus. Sensory (taste) fibres have cell bodies in geniculate ganglion of facial and end centrally in nucleus of tractus solitarius.

Principal branches are greater (superficial) petrosa and chorda tympani.

THE VESTIBULO-COCHLEAR (AUDITORY) NERVE (see p. 308).—*Origin*—*Superficial*: Between pons and inferior cerebellar peduncle in two parts—*cochlear* (hearing) and *vestibular* (equilibrium). *Deep*: Fibres end in auditory and vestibular nuclei in floor of 4th ventricle.

Course. Passes round inferior cerebellar peduncle to posterior border of middle cerebellar peduncle with facial, it then enters the internal auditory meatus with the facial nerve.

Distribution: *Cochlear*, supplies cochlea; *vestibular*, to utricle, saccule and semicircular canals (see p. 307). The former, the nerve of hearing, arises from the cells of the spiral ganglion of the cochlea; the latter, the nerve of equilibration, takes origin from cells of vestibular ganglion.

THE GLOSŒO-PHARYNGEAL NERVE.—*Origin*—*Superficial*: From the upper part of the medulla, in the groove between the olive and inferior cerebellar peduncle. *Deep*: Floor of 4th ventricle.

Course: Passes laterally over the flocculus to the jugular foramen, by which it leaves the skull with the inferior petrosal sinus in a separate tube of dura mater and in front of vagus and accessory, making a deep notch in petrous part of temporal bone (aqueduct

of cochlea opens here). It presents near point of exit two ganglionic enlargements—the superior and inferior. Issuing from the skull, the nerve passes downwards and laterally between the internal carotid artery and jugular vein, and then forwards over the internal carotid artery, downwards behind the muscles attached to the styloid process, to reach the lower border of the stylo-pharyngeus. Thence it inclines medially on the middle constrictor beneath the hyoglossus to the tongue, pharynx, and tonsil.

The superior ganglion : The smaller of the two, is situated at the upper part of the notch in the petrous bone through which the nerve passes. It involves only the lateral part of the trunk of the nerve.

The **inferior ganglion** is placed in lower part of notch on the inferior border of the petrous bone.

Branches

Connecting, from inferior ganglion:

- (a) To superior cervical ganglion of sympathetic.
- (b) To auricular of vagus.
- ° (c) To superior ganglion of vagus.

Meningeal: To inferior surface of tentorium cerebelli.

Tympanic : Arising from the inferior ganglion, enters a minute canal in the bone between jugular foramen and carotid canal to reach the medial wall of the tympanum; runs in a groove over the promontory, giving off several branches, and, after communicating with the facial, is continued forwards as the *lesser (superficial) petrosal nerve*. This nerve pierces the petrous portion of the temporal to reach the middle fossa just lateral to the hiatus for greater petrosal nerve, and, passing through the foramen ovale or foramen innominatum, ends in the otic ganglion, for relay to parotid gland.

Pharyngeal (3 or 4): Cross the internal carotid and join opposite the middle constrictor with pharyngeal of vagus and sympathetic, to form pharyngeal plexus, supplying the mucous membrane of the oro-pharynx.

Sinu-carotid : Supplies carotid sinus (pressoreceptor) and carotid body (chemoreceptor).

Muscular : To stylo-pharyngeus.

Tonsillar : To the tonsil forming plexus, and thence to oro-pharyngeal isthmus and soft palate, accompany pharyngeal branches.

Lingual (2) : One branch distributed to the base supplying the vallate papillæ, the other to the posterior $\frac{1}{3}$ of side of the tongue.

Special functions : Nerve of sensation to the mucous membrane of pharynx, oro-pharyngeal isthmus and tonsil; of motion to stylo-pharyngeus muscle; of taste to the posterior $\frac{1}{3}$ of the tongue; secreto-motor to parotid gland and mucous glands of pharynx and posterior $\frac{1}{3}$ of tongue (from inferior salivary nucleus).

THE VAGUS NERVE—Origin—Superficial : Sulcus between inferior cerebellar peduncle and olive. *Deep :* Vagal triangle on floor of 4th ventricle and nucleus ambiguus of the medulla

Course : Passes from origin over the flocculus to jugular foramen, through which it passes in same sheath with accessory and behind the glosso-pharyngeal; in the foramen it presents the *superior ganglion*. Upon leaving the foramen, it receives a branch from the cranial root of the accessory, and forms an enlargement, the *inferior ganglion*. The cranial root of the accessory nerve joins the inferior ganglion. Thence the nerve passes down in the carotid sheath, behind and between the artery and vein, to the root of the neck, where its course on each side of the body becomes different.

The *right* nerve passes between 1st part of subclavian artery and subclavian vein, and down by side of trachea and behind right innominate vein to posterior part of the root of the right lung, forming the right posterior pulmonary plexus; thence proceed two cords, which run down on the œsophagus, communicate with nerve of opposite side (œsophageal plexus), join below into one trunk, which lies behind œsophagus and, passing through œsophageal orifice

in diaphragm, is distributed to the posterior surface of the stomach, joining celiac and splenic plexuses.

The *left* nerve passes down between the left subclavian and carotid arteries, and behind the left innominate vein, where the left phrenic crosses it; thence to left of the arch of aorta to posterior surface of root of left lung, forming the left posterior pulmonary plexus; then along the anterior surface of œsophagus through diaphragm, to be distributed on the anterior surface of stomach, and joins hepatic plexus.

Branches

Meningeal : From the superior ganglion, passes backwards to the dura mater of the posterior fossa.

Auricular : From the superior ganglion, communicates with the inferior ganglion of the glosso-pharyngeal, and enters a foramen between the root of the styloid process and jugular fossa. It passes through the temporal bone communicating with the facial, and emerges by the auricular fissure just behind the external auditory meatus to supply adjacent skin of meatus and auricle and part of tympanic membrane.

Pharyngeal : Principally formed by fibres from the cranial root of accessory, passes between the two carotid arteries to the pharyngeal plexus. It is the motor nerve to the constrictors of the pharynx and muscles of soft palate.

Superior laryngeal : From the inferior ganglion, passes down deep to internal carotid artery, where it divides into motor *external laryngeal nerve*, which supplies the crico-thyroid and crico-pharyngeus muscles and sensory *internal laryngeal nerve*, which, passing through thyro-hyoid membrane, is distributed to the mucous membrane of the piriform fossa and larynx, and communicates with a branch from the recurrent laryngeal.

Recurrent laryngeal : The *right* nerve arises in front of subclavian artery, winds back round it, and passes up behind common carotid and inferior thyroid arteries to right side of trachea. The *left* nerve arises to left of arch of aorta, round which it winds below

the ligamentum arteriosum and passes up by left side of trachea. Each nerve ascends in a groove between trachea and œsophagus, and enters larynx by passing under lower border of inferior constrictor muscle. The nerve supplies all the muscles of the larynx (except the crico-thyroid), and a branch to crico-pharyngeus.

NOTE.—This nerve approaches the larynx by passing behind or between the terminal branches of the inferior thyroid artery.

Cervical cardiac (2 or 3): *Superior* are small; join cardiac of sympathetic. *Inferior*, one on either side, arise just above 1st rib; the *right* one passes by the side of innominate artery and joins deep cardiac plexus; the *left* one descends to left of the arch of the aorta, and joins superficial cardiac plexus.

Thoracic cardiac: *Right* ones from the trunk of the nerve. *Left* ones arise from left recurrent laryngeal. Both end in deep cardiac plexus.

Bronchial (2 or 3): To anterior part of root of lung, joining with sympathetic to form the anterior pulmonary plexus. Numerous branches to posterior part of root of lung, which join branches from 2nd, 3rd, and 4th thoracic ganglia of sympathetic, forming the posterior pulmonary plexus.

Œsophageal: form œsophageal plexus in which both nerves intermingle, below level of lung roots.

Gastric: The *right* nerve is distributed to posterior part of stomach, and ends in the cœliac and splenic plexuses. The *left* supplies the anterior surface and ends in the hepatic plexus. There is, however, some admixture of the two in the œsophageal plexus.

NOTE.—The branches of the vagus to the alimentary canal are *augmentor* and at the same time relax the sphincters; this is in contrast with the cardiac branches, which are *inhibitor*.

THE ACCESSORY NERVE: The spinal part of this nerve (upper five cervical segments) arises from the lateral part of the anterior horn of the cervical spinal cord, and supplies the sterno-mastoid and trapezius. The cranial (bulbar) part arises from the lower part of the nucleus ambiguus, issues from side of medulla,

becomes incorporated with the ⁶vagus, and is distributed through that nerve to the pharyngeal and laryngeal muscles.

NOTE.—The nucleus ambiguus is the motor nucleus for the pharynx, larynx, soft palate and stylo-pharyngeus.

Course : The cranial root passes out of the jugular foramen close to the vagus, and joins its inferior ganglion. The cervical root leaves the cord between the anterior and posterior nerve-roots and runs up behind ligamentum denticulatum to enter the skull through foramen magnum and passes to jugular foramen; it is enclosed in the same sheath of dura mater as the vagus. Issuing from the foramen it passes downwards between internal carotid artery and internal jugular vein, and then backwards superficial to the internal jugular vein to upper part of sterno-mastoid, which it pierces, at the same time communicating with the branch to the muscle from the 2nd cervical nerve. Crossing the occipital part of the posterior triangle, it enters the under surface of the trapezius, where it joins with branches of the 3rd and 4th cervical nerves to form a plexus in the substance of the muscle.

THE HYPOGLOSSAL NERVE—*Origin*—*Superficial* : By two bundles, from the groove between the olive and pyramid. *Deep* : Nucleus beneath hypoglossal triangle in floor of 4th ventricle.

Course : The nerve passes through anterior condylar canal, then downwards and forwards between vagus and accessory, between internal carotid artery and internal jugular vein to the lower border of the digastric muscle; curving round the occipital artery, it crosses the external carotid and lingual arteries, and, passing between the mylo-hyoid and hyoglossus muscles, ends by dividing into branches on the genioglossus.

Branches

Communicating : From the inferior ganglion of the vagus.

From the superior cervical ganglion of the sympathetic.

From the loop between 1st and 2nd cervical.

• With the lingual of the trigeminal, on the hyoglossus.

Distributing :

Meningeal: From C. 1. Enters hypoglossal canal to dura of posterior fossa.

Superior root of ansa cervicalis (descendens hypoglossi): A slender branch given off as the nerve hooks round occipital artery, passes down over carotid sheath, joining in a loop (ansa cervicalis) with branch from 2nd and 3rd cervical (descending cervical nerve, or inferior root of ansa); from this loop muscular branches are given to sterno-hyoid, sterno-thyroid, and the two bellies of the omo-hyoid. *This branch, and those to thyro-hyoid and genio-hyoid, do not arise from hypoglossal nucleus, but are derived from communication above with 1st cervical, and merely pass down with hypoglossal.*

Thyro-hyoid: Passes round greater horn of hyoid bone to supply thyro-hyoid (from C. 1).

Muscular: To stylo-glossus, hyoglossus, genio-glossus and intrinsic muscles of the tongue. Genio-hyoid, from C. 1.

THE SPINAL NERVES

There are 31 pairs of spinal nerves—viz.: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal. Each nerve arises from the spinal cord by a ventral (or anterior) (motor) and a dorsal (or posterior) (sensory) root, the latter having a ganglion developed upon it. These roots join together in the intervertebral foramen, and upon issuing from it immediately split up again into two parts, the anterior and posterior primary rami, each containing fibres from the two roots. The anterior primary rami supply the parts in front of the spine, the posterior primary rami the parts behind that column.

The posterior primary rami of the spinal nerves are generally smaller than the anterior, and pass directly backwards, each quickly dividing into a *lateral* and a *medial* branch, to supply the muscles and skin behind the spine. To this general rule there are a few exceptions, as posterior primary rami of the

"1st cervical, the 4th and 5th sacral, and the coccygeal nerves do not thus subdivide."

Each anterior primary ramus receives a grey communicating branch from the corresponding ganglion of the sympathetic trunk. The anterior primary rami give white branches to the sympathetic ganglia from the 1st thoracic to the 2nd lumbar, and from the 2nd and 3rd sacral nerves white branches are given to the parasympathetic.

THE CERVICAL NERVES

THE POSTERIOR PRIMARY RAMI

The first cervical nerve : The posterior primary ramus of the 1st cervical nerve passes backwards beneath the vertebral artery on the posterior arch of atlas and, entering the suboccipital triangle, divides into branches to supply the obliquus capitis inferior, the recti posteriores major and minor, the obliquus capitis superior, and the semispinalis capitis.

The second cervical nerve : The medial branch of this is the *great occipital nerve*, and is a specially large and important cutaneous nerve, supplying the posterior half of the scalp. It passes through the semispinalis capitis and trapezius, and ascends with the occipital artery to the back of the scalp, communicating with the lesser occipital nerve.

With the exception of the 1st cervical nerve, the posterior primary rami of the cervical nerves divide into:

Lateral branches : For the muscles behind the spine.

Medial branches : Larger than the lateral branches, they become cutaneous, supplying the muscles on their way. The branch from the third cervical nerve supplies the skin at the base of the occiput (*third occipital*). The medial branches from the 7th and 8th end in the muscles.

THE ANTERIOR PRIMARY RAMI

The anterior primary rami of the first four cervical nerves form the cervical plexus, and those of the lower

four, with part of that of the 1st thoracic nerve, compose the brachial plexus.

The anterior primary rami of the 1st and 2nd cervical nerves differ in their course from the rest.

The anterior primary ramus of the **1st cervical nerve** passes laterally in the groove on the posterior arch of the atlas to the lateral side of the lateral mass, lying medial to the vertebral artery, and giving branches to the rectus capitis lateralis, obliquus capitis, and rectus capitis anterior. It joins the 2nd nerve and the hypoglossal nerve.

The 2nd cervical nerve : The anterior primary ramus of this nerve winds forward around the atlanto-axial joint, and divides into an *ascending* part, which joins the 1st cervical, and a *descending* part, which joins the 3rd cervical nerve.

The CERVICAL PLEXUS is formed by the union of the anterior primary rami of the first four cervical nerves after each has received its grey ramus from the superior cervical ganglion. It is situated between the sterno-mastoid and the scalenus medius muscles deep to the prevertebral fascia. Each nerve divides into an *ascending branch*, which connects it with the nerve above, and a *descending branch*, which joins it to the nerve below. From the loop between the 2nd and 3rd nerves cutaneous branches are given off to the head and neck, and from the union of the 3rd and 4th nerves superficial branches pass to the shoulder and chest, together with muscular and communicating branches.

I. SUPERFICIAL ASCENDING BRANCHES:

Transverse cervical (anterior cutaneous nerve of neck) : From loop between 2nd and 3rd nerves, passes forwards over the middle of the sterno-mastoid, perforates the cervical fascia, and divides beneath platysma into:

Ascending branch : Communicates with the facial and becomes cutaneous, supplies front of upper half of neck.

Descending : Supplies skin as low as sternal notch.

Great auricular : From 2nd and 3rd. Winds round posterior margin of sterno-mastoid to reach parotid gland. Gives off:

• **Facial** : To skin of face over parotid and parotid fascia.

Auricular : To back part of pinna and lateral surface below external auditory meatus, communicates with posterior auricular.

Mastoid : Supplying skin over mastoid process, joining with posterior auricular of facial and lesser occipital.

Lesser occipital : From 2nd, ascends along posterior border of sterno-mastoid to scalp, lying between ear and occipital artery; supplies skin.

Branch :

Auricular : Supplies tip of cranial surface of auricle.

NOTE.—At the posterior border of the sterno-mastoid this nerve winds round the emerging spinal accessory nerve.

2. SUPERFICIAL DESCENDING BRANCHES:

Supraclavicular : From 3rd and 4th.

Branches:

Medial : To skin as far as middle line and down to anterior axial line (supra-sternal).

Intermediate : To skin over pectoral muscle; may pierce clavicle.

• **Lateral** : To skin of shoulder (supra-acromial).

3. DEEP BRANCHES (MEDIAL):

Communicating : From loop between 1st and 2nd, joins superior cervical ganglion, hypoglossal, and vagus nerves.

Inferior root of ansa cervicalis (descending cervical nerve) : From 2nd and 3rd, forms a loop with descending branch of hypoglossal in front of carotid vessels (ansa cervicalis).

Muscular : To prevertebral muscles and through communications with hypoglossal to genio- and thyrohyoid, and to ansa cervicalis.

• **Phrenic** : From 4th, with branches from 3rd and 5th; lies in front of scalenus anterior, descends medially on it in front of subclavian artery to enter the chest, having crossed the internal mammary artery at origin, behind the subclavian vein. In the thorax it descends in front of the root of the lung, being between the pericardium and the mediastinal pleura, to the diaphragm, which it perforates, and is

distributed on its abdominal surface. The right nerve lies to right of right innominate vein and superior vena cava. Passes through caval orifice of diaphragm. The left nerve in the neck is crossed by the thoracic duct, and below crosses left vagus and arch of aorta, and is longer than the right. Filaments from each supply the pericardium, pleura and peritoneum.

4. DEEP BRANCHES (LATERAL):

Communicating : To accessory in sterno-mastoid and trapezius muscles (proprioceptive).

Muscular : To sterno-mastoid from the 2nd and 3rd, levator scapulæ from the 3rd and 4th, scalenus medius from the 3rd and 4th, and trapezius from the 3rd and 4th. Scalenus anterior from 4th and 5th.

THE BRACHIAL PLEXUS

The BRACHIAL PLEXUS is formed by the union and subsequent division of the anterior primary rami of the lower four cervical and part of anterior ramus of the 1st thoracic nerves. The 5th and 6th cervical receive grey rami from the middle, and 7th and 8th from inferior cervical ganglion. The following is the usual method of union and redivision:

The 5th and 6th cervical join together at lateral border of the scalenus anterior to form an upper trunk.

The 7th cervical forms a middle trunk.

The 8th cervical and the 1st thoracic form a lower trunk.

Each of these trunks then subdivides into anterior and posterior divisions.

The anterior divisions from the upper and middle trunks form the *lateral cord* of the plexus.

The anterior division of the lower trunk forms the *medial cord* of the plexus.

The posterior divisions of all the trunks unite to form the *posterior cord*.

The subjoined scheme will make this arrangement clear (Fig. 53):

C5 } Upper	nk	{ Posterior	Lateral cord	Posterior cord.
C6 } Middle	trunk	{ Anterior		
		{ Anterior		
C8 } Lower	trunk	{ Posterior	Medial cord.	
D1 } Lower	trunk	{ Anterior		

The nerve roots lie between scalenus anterior and medius, the trunks cross the posterior triangle. Divisions lie behind the clavicle, and cords enter

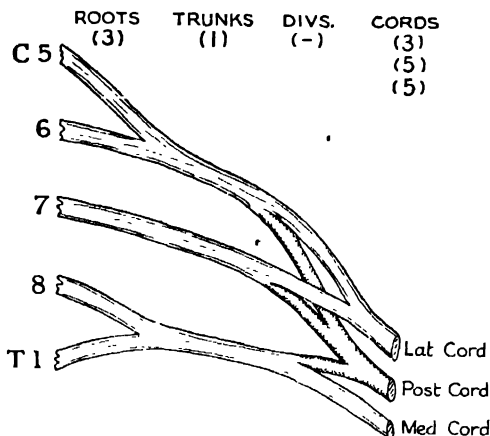


FIG. -BASIC PLAN OF THE BRACHIAL PLEXUS.

Figures in brackets give the number of branches from its constituents (see text).

axilla. Cords converge from above on axillary artery, second part of which they surround, behind pectoralis minor. Here they lie medial, lateral and posterior to the artery, hence their names. Branches from the cords lie around third part of axillary artery.

Branches from the nerve roots

Dorsalis scapulæ (nerve to the rhomboids): Posteriorly from the 5th cervical, passes through scalenus medius to the medial border of the scapula, then under levator scapulæ, supplying it, and ending on the

anterior surface of the rhomboid muscles. Runs with deep branch of transverse cervical artery on serratus posterior superior.

Nerve to the subclavius: Anteriorly from the 5th and 6th cervical, passes downwards in front of the 3rd part of the subclavian artery and vein to the deep surface of the subclavius; often communicates with phrenic. This communication is the *accessory phrenic nerve* and passes into the thorax in front of the subclavian vein.

Long thoracic (nerve to serratus anterior): Posteriorly from 5th, 6th and 7th. 5th and 6th join in scalenus medius, leave its lateral border, joined in axilla by 7th, which passes in front of scalenus medius. Nerve descends behind mid-axillary line under fascia on serratus anterior, which muscle it supplies segmentally (5th to upper two digitations, 6th to next two, 7th to last four).

Branch from the trunks

Suprascapular: From the union of the 5th and 6th cervical, passes beneath trapezius to upper border of scapula, enters supraspinous fossa through suprascapular notch, gives off two branches to the supraspinatus, and an articular one to the shoulder-joint; thence it passes to the infraspinous fossa, and ends in the infraspinatus.

Branches from the cords

The several nerves are given off as follows:

<i>Lateral Cord.</i>	<i>Medial Cord.</i>	<i>Posterior Cord.</i>
Lateral pectoral.	Medial pectoral.	3 subscapulars.
Musculo-cutaneous.	Medial cutaneous nerve of arm	Axillary
Lateral head of median.	Medial cutaneous nerve of forearm.	(circumflex).
	Ulnar.	Radial
	Medial head of median.	(musculo-spiral).

Lateral pectoral: From the 5th, 6th, and 7th cervical, lateral cord: crosses over axillary artery and pierces clavipectoral fascia to reach under surface of the pectoralis major, in which it communicates with medial pectoral.

Medial pectoral: From 8th cervical and 1st thoracic,

medial cord: passes between axillary artery and vein to the pectoralis minor, which it pierces to end in pectoralis major.

Subscapular: Three (posterior cord).

Upper: From the 6th cervical: the smallest, supplies upper part of subscapularis.

Middle (nerve to latissimus dorsi): From the 6th, 7th, and 8th cervical: runs along lower border of subscapularis with the subscapular vessels to supply the latissimus dorsi.

Lower: From the 6th and 7th cervical: ends in the teres major, having previously given a filament to the subscapularis.

Axillary (circumflex): From the 5th and 6th cervical, posterior cord: passes backwards with posterior circumflex vessels at the lower border of the subscapularis through quadrilateral space formed by teres major, teres minor, long head of the triceps and humerus, and, having given an *articular* branch to the shoulder-joint, divides into—

Anterior branch: Winds round neck of the humerus, supplying deltoid and skin.

Posterior branch: Gives a branch to teres minor, which has a gangliform swelling upon it; also branches to deltoid and skin (*upper lateral cutaneous of arm*).

Medial cutaneous nerve of arm: From the 1st thoracic, medial cord: lies to medial side of axillary vein, communicates with intercosto-brachial, then descends along medial side of brachial vessels to middle of the arm, where it becomes cutaneous and supplies skin of medial side as far as medial epicondyle. It communicates with the posterior branch of the medial cutaneous nerve of forearm.

Medial cutaneous nerve of forearm: From the 8th cervical and 1st thoracic, medial cord: lies in front of 3rd part of axillary artery, becomes cutaneous about middle of arm, and divides into two branches.

Anterior: Passes behind median basilic vein, supplies front of medial side of forearm as low as wrist.

Posterior: Winds over medial epicondyle, supply-

ing the back of medial side of forearm to about the middle.

Musculo-cutaneous: From the 5th, 6th, and 7th cervical, lateral cord; perforates coraco-brachialis, passing to lateral side of arm between biceps and brachialis, supplying the three named muscles; filaments also may be given to the elbow-joint; becomes cutaneous as *lateral cutaneous nerve of forearm* just above elbow, and, passing behind median cephalic vein, divides into—

Anterior cutaneous branch: Passes along radial border of forearm, supplying ball of thumb and joining the radial.

Posterior cutaneous branch: Supplies skin of lower third of back of forearm on the radial side; joins branches of radial (posterior cutaneous branch).

Median: From the 5th, 6th, 7th, and 8th cervical and the 1st thoracic: arises by two roots, one from the lateral cord, the other from the medial cord of the plexus, which crosses 3rd part of axillary artery to join the lateral root. At first the nerve lies lateral to the axillary artery, but about the middle of the arm it crosses the brachial artery to reach its medial side; it then passes between the two heads of the pronator teres, and is continued straight down the forearm upon the flexor profundus, and beneath the flexor sublimis (to the deep surface of which it clings); at the wrist it lies under the palmaris longus and between the tendons of the flexor sublimis and flexor carpi radialis. Passing beneath the flexor retinaculum, it becomes somewhat flattened, and divides into two parts to supply the lateral $3\frac{1}{2}$ fingers.

Branches in the forearm

Articular: To elbow-joint.

Muscular: To pronator teres, flexor carpi radialis, palmaris longus, and flexor digitorum sublimis.

Anterior interosseous: Is given off just below the elbow-joint. It passes down lateral to the anterior interosseous artery on the membrane, between the flexor profundus and flexor pollicis longus, to end in the deep surface of pronator quadratus. Supplies

flexor pollicis longus, pronator quadratus, and lateral half of flexor digitorum profundus. Sensory to periosteum and interosseous membrane.

Palmar cutaneous : Pierces fascia just above flexor retinaculum, ends in the skin of the palm, joining the palmar cutaneous of the ulnar nerve.

Terminal branches in the hand

* *Muscular to thumb* : Supplies abductor, opponens, and flexor pollicis brevis. This branch recurves around lower border of flexor retinaculum.

Palmar digital : Five in number, supplying lateral $3\frac{1}{2}$ fingers. 1st and 2nd supply the thumb, 3rd to radial side of index finger also supplies 1st lumbrical; 4th to adjacent sides of index and middle fingers and supplies 2nd lumbrical; 5th supplies adjacent sides of ring and middle fingers, and joins a branch of the ulnar, giving sometimes a branch to the 3rd lumbrical.

Ulnar : From the 8th cervical and 1st thoracic, medial cord: also by lateral head from C. 7 in 95 per cent. of individuals for supply of flexor carpi ulnaris (Wilfred Harris): passes down the medial side of axillary and brachial arteries to middle of arm; it then runs with ulnar collateral artery through medial intermuscular septum to groove between olecranon and medial epicondyle. Thence it passes between the two heads of the flexor carpi ulnaris and descends under cover of that muscle, along ulnar side of forearm and medial to ulnar artery, as far as the pisiform bone; it then courses over the flexor retinaculum lateral to that bone, and divides into superficial and deep palmar branches.

Branches in the forearm

* *Articular* : To elbow and wrist joints.

* *Muscular* : To flexor carpi ulnaris and medial half of flexor digitorum profundus.

Cutaneous : Arises near middle of forearm, and divides into *superficial* to skin of forearm, and *palmar*, accompanies ulnar artery to hand, supplying the palm; joins the cutaneous of median.

Dorsal cutaneous : Comes off about 3 inches above pisiform bone, winds round ulna beneath flexor carpi

ulnaris, supplies medial side of little finger, and adjacent sides of ring and little fingers on their dorsal aspects.

Palmar branches

Superficial terminal branch : Supplies palmaris brevis, ends in two digital branches for medial $1\frac{1}{2}$ fingers, the lateral one communicating with the median.

Deep terminal branch : Accompanies deep palmar arch; it supplies the small muscles of the 5th finger, and gives two branches to each interosseous space, one for each set of interossei; branches are also given to the two medial lumbrical muscles. In the space between the thumb and index finger the nerve ends by supplying the adductor pollicis and 1st palmar interosseous (sometimes named medial head of flexor pollicis brevis).

Radial : From the 5th, 6th, 7th, and 8th cervical, posterior cord; winds round between lateral and medial heads of triceps in the spiral groove with profunda brachii artery to the lateral side of arm. Piercing the lateral intermuscular septum, it passes to the front of the lateral epicondyle between the brachio-radialis and brachialis, where it gives off the posterior interosseous branch.

Branches

Muscular : To the three heads of the triceps, to the anconeus, brachio-radialis, extensor carpi radialis longus and brachialis.

Posterior cutaneous nerve of arm comes off in axilla, supplies skin on back of arm to near olecranon

The *lower lateral cutaneous nerve of arm* perforates lateral head of triceps, accompanies cephalic vein to elbow, supplying the skin of the lower half of arm in front.

The *posterior cutaneous nerve of forearm* supplies skin of lower part of arm, and back part of radial side of forearm as far as the wrist.

Posterior interosseous : Reaches the back of the forearm by piercing the supinator; there it passes between

the superficial and deep layers of muscles to about middle of forearm, where it passes deep to extensor pollicis longus to reach the interosseous membrane, on which it lies as far as the wrist; there it ends in a gangliform enlargement, from which there are given off filaments to the ligaments, etc. Supplies supinator, extensors carpi radialis brevis, digitorum communis, digiti minimi, carpi ulnaris, pollicis longus and brevis, and indicis and abductor pollicis longus.

The radial nerve then passes down lateral to the radial artery, under cover of the brachio-radialis, to within 3 inches of the lower end of the radius, where the nerve passes backwards beneath the tendon of the brachio-radialis, and, becoming cutaneous by piercing the fascia on lateral side of forearm, divides into two branches:

Lateral: Supplies ball and lateral border of thumb, joining with the lateral cutaneous nerve of forearm

Medial: Joins a branch of the lateral cutaneous and dorsal of ulnar. It gives off four dorsal digital nerves, thus: 1st to medial side of thumb, 2nd to lateral side of index, 3rd to adjacent sides of index and middle, 4th to adjacent sides of middle and ring fingers. It thus corresponds in its distribution with the median nerve.

THE THORACIC NERVES

These are twelve in number. The 1st comes out between the 1st and 2nd thoracic vertebrae, and the greater part joins the brachial plexus. The last nerve emerges from between the 12th thoracic and 1st lumbar vertebrae. Each nerve at its exit from the intervertebral foramen divides into an anterior and posterior primary ramus. The 1st and 12th nerves, however, require a separate description.

The POSTERIOR PRIMARY RAMI, or *dorsal* branches, pass backwards between the transverse processes and divide into lateral and medial branches, which emerge on either side of the middle division of the sacro-

spinalis (longissimus thoracis), and supply the muscles of the back. *Cutaneous* branches are derived from each of these sets, the six upper ones coming from the medial branches and the six lower ones from the lateral branches

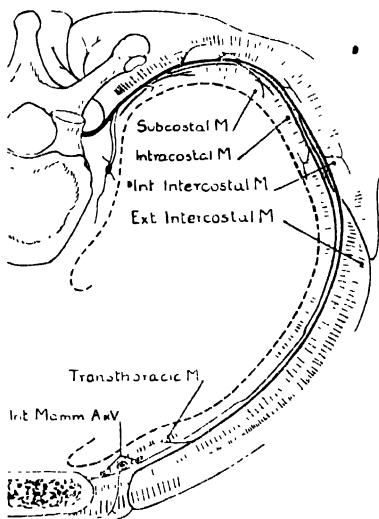


FIG. 54.—DIAGRAM OF AN INTERCOSTAL SPACE, SHOWING THE THREE PLANES OF MUSCLE, AND THE DETAILED COURSE OF THE THORACIC NERVE.

The dotted line represents the pleura.

The ANTERIOR PRIMARY RAMI, or *intercostal nerves*, are twelve in number on each side; each gives a white ramus to the corresponding sympathetic ganglion and receives a grey ramus from it

The UPPER six pass forwards (see Fig. 54) in the intercostal spaces below the vessels, lying at first between the pleura and posterior intercostal membrane, then between the intracostal and internal inter-

costal muscles; as they approach the front they lie between the internal intercostal muscle and the pleura, extending forwards to the sternum, and crossing the internal mammary artery, to end as the *anterior cutaneous nerves* of the thorax by perforating internal intercostal and pectoralis major.

Branches

Collateral : Comes off posteriorly, runs in neuro-vascular plane in lower part of space. Supplies intercostal muscles, parietal pleura and periosteum of ribs.

Lateral cutaneous : Given off midway between head of rib and sternum. The 1st intercostal nerve has no lateral cutaneous branch. Each branch pierces the intercostal muscles, and divides into anterior and posterior branches, which supply the mammary gland and skin.

The lateral cutaneous branch of the 2nd nerve, or *intercosto-brachial*, does not divide; it crosses the axilla, joins the medial cutaneous nerve of arm and supplies the skin of the medial side of the arm.

The LOWER six pass like the upper ones to the front of the intercostal spaces, thence between the internal oblique and transversus abdominis to the sheath of the rectus, behind which they pass medially and then perforate that muscle to terminate near the middle line as *anterior cutaneous branches*

Branches

Collateral : as above.

Lateral cutaneous : Supply the skin of the abdomen, having anterior and posterior branches.

PECULIAR THORACIC NERVES : The 1st nerve : its *anterior primary ramus* is mostly consumed in the brachial plexus, which it reaches by passing obliquely across the neck of the 1st rib, but a small branch is given off to the 1st intercostal space, which has no lateral cutaneous branch. The 12th nerve does not lie in an intercostal space, but below the 12th rib in front of the *quadratus lumborum*; it then pierces the lumbar fascia, passing forwards between transversus abdominis and internal oblique to end by

perforating rectus; is remarkable for the large size of its *lateral cutaneous branch*, which does not divide, but, piercing internal and external oblique, passes over iliac crest and supplies skin over gluteal region as far down as greater trochanter.

THE LUMBAR NERVES

These are five on each side.

The POSTERIOR PRIMARY RAMI pass backwards between the transverse processes and divide into medial and lateral branches. These are seen to be separated by the longissimus thoracis. The medial branches end in the muscles; all the lateral supply muscles and the upper three also give large cutaneous branches to gluteal region.

The ANTERIOR PRIMARY RAMI increase in size from above downwards, the upper two giving white rami and all five receiving grey rami from the corresponding sympathetic ganglia; the upper three and greater part of the 4th form the lumbar plexus; the rest of the 4th joins with the 5th to form the *lumbo-sacral trunk*.

LUMBAR PLEXUS: Formed in the psoas by the communications of the anterior primary rami of the four upper lumbar nerves in the following manner:

The 1st gives off the ilio-hypogastric, the ilio-inguinal, a branch to the genito-femoral, and a communicating branch to the 12th thoracic and 2nd lumbar.

The 2nd gives off branches to the genito-femoral and lateral cutaneous of thigh, and a communicating branch to the 3rd, which also forms part of the femoral and obturator.

The 3rd gives off part of the lateral cutaneous of thigh, of the femoral, and of the obturator.

The 4th gives off a branch to the femoral, one to the obturator, and a communicating one to the 5th.

Muscular branches are supplied to the psoas and quadratus lumborum.

Branches

Ilio-hypogastric: From 1st lumbar, appears at upper part of lateral border of psoas, crosses quadratus

lumborum to iliac crest, and, piercing the transversus abdominis, divides into:

Lateral branch : Pierces two oblique muscles, crosses iliac crest behind lateral cutaneous of 12th thoracic nerve to skin of buttock.

Anterior branch : Pierces internal oblique near anterior superior iliac spine and then external oblique aponeurosis above superficial inguinal ring to end in skin of hypogastric region.

Ilio-inguinal : From 1st lumbar; passes over quadratus lumborum and iliacus to iliac crest, pierces the transversus abdominis and internal oblique; it then accompanies the cord through canal and superficial inguinal ring, and is distributed to the skin of the groin and the scrotum.

Genito-femoral : From 2nd lumbar, with a branch from 1st. Passes on the psoas to inguinal ligament to divide into:

Genital branch : Crosses external iliac artery, enters inguinal canal through deep inguinal ring, accompanies spermatic cord, and supplies the cremaster muscle. In the female (very small) it accompanies the round ligament of the uterus (L. 2).

Femoral branch : Passes beneath inguinal ligament, perforates fascia on lateral side of femoral artery, communicates with intermediate cutaneous nerve, supplies small area of skin of upper and front part of thigh (L. 1).

Lateral cutaneous nerve of thigh : From loop between 2nd and 3rd lumbar; perforates middle of lateral border of psoas, runs obliquely across iliacus, and enters thigh through fibrous sling beneath lateral part of inguinal ligament, where it divides into:

Anterior branch : Contained at first in a tube of the fascia lata; supplies lateral part of anterior surface of thigh.

Posterior branch : Supplies lateral surface of thigh to the middle.

Obturator : From 2nd, 3rd, and 4th lumbar anterior to corresponding branches to femoral nerve; passes from medial border of psoas, near brim of pelvis and above obturator artery, but below external iliac, to

canal in upper part of obturator foramen. In this canal it divides into:

Anterior branch : Descends in front of adductor brevis, behind pectineus and adductor longus; it supplies the hip-joint, gracilis, adductor longus, adductor brevis, femoral artery, and a cutaneous branch to plexus under sartorius, sometimes to pectineus; communicates with accessory obturator when this is present. Supplies skin above adductor tubercle.

Posterior : Passes through obturator externus and behind adductor brevis; it supplies a large branch to adductor magnus, and gives branches also to obturator externus, adductor brevis when the latter is not supplied by the anterior branch, and a branch along popliteal artery to knee-joint

Accessory obturator : From 3rd and 4th lumbar or from obturator trunk; when present it passes down on medial side of psoas, over superior ramus of pubis, under pectineus, and supplies pectineus and hip-joint; communicates with the anterior branch of the obturator

Femoral : From 2nd, 3rd, and 4th lumbar, roots being given off posterior to those of obturator nerve; emerges from lower part of lateral border of psoas, and descends between that muscle and the iliacus, lying on the lateral side of the external iliac vessels. It supplies the *iliacus* and *femoral artery* whilst in the pelvis, and on emerging from it, beneath the inguinal ligament, it divides into branches, between which the lateral circumflex artery runs outwards

Muscular branches :

1. *To pectineus :* Generally two, which pass medially under femoral vessels to muscle.

2. *To sartorius :* Given off with intermediate cutaneous.

3. *To rectus :* Which gives branch to hip-joint.

4. *To vastus lateralis :* Which accompanies descending branch of the lateral circumflex artery, and gives an *articular* branch to the knee-joint

5. *To vastus medialis :* Which accompanies the deep branch of the descending genicular artery, and gives

off an *articular* branch to the knee-joint.

6. *To vastus intermedius* : Two or three, the medial one supplying *articularis genu* and knee-joint.

Cutaneous branches :

1. *Intermediate cutaneous* : Pierces fascia lata 3 inches below the inguinal ligament, dividing into two branches to supply the skin of the front of the thigh as far as the knee. Communicates with femoral of genito-femoral and medial cutaneous, and gives a branch to the sartorius.

2. *Medial cutaneous* : Passes obliquely across to medial side of femoral artery, and divides into: *Anterior branch* : pierces fascia lata in lower $\frac{1}{3}$ of thigh; supplies skin of the lower $\frac{1}{3}$ of medial side of thigh; communicates near the knee with saphenous. *Posterior branch* : Passes down posterior border of sartorius to knee, giving branches to plexus near that muscle, and finally is distributed to skin of the leg; communicates in the thigh with the obturator and the saphenous nerves, forming in subsartorial canal a plexiform interlacement, the *subsartorial plexus*.

3. *Saphenous* : Accompanies femoral artery, lying on its lateral side as far as subsartorial canal, in which it crosses artery; leaves canal at its lower end by passing medially beneath sartorius. Here it becomes subcutaneous, and is continued with the long saphenous vein along medial side of leg, behind medial border of tibia, and, passing in front of medial malleolus, is distributed on medial side of foot as far as ball of great toe. In its course it gives off a branch to plexus under sartorius formed by obturator and medial cutaneous nerves, to patellar plexus, and below the knee to the skin on the anterior and medial surfaces of the leg (*infra-patellar branch*).

4. *Patellar plexus* : This is formed by communications between the anterior branch of the medial cutaneous, branches of the intermediate and lateral cutaneous nerves, together with the infra-patellar branch of the saphenous nerve.

THE SACRAL NERVES

• Five in number. The roots of origin are in the *cauda equina*, and in this region the posterior root ganglia are placed inside the spinal canal, though outside the dura mater. Each nerve divides into anterior and posterior primary rami.

The POSTERIOR PRIMARY RAMI of the upper four emerge from the posterior sacral foramina, the fifth at the lower end of the spinal canal; the upper three nerves divide into medial and lateral branches, the former supplying the multifidus spinæ, the latter the skin over sacrum, coccyx, and posterior gluteal region; the two lower nerves do not divide, and supply filaments to skin over coccyx, the 5th communicating with the coccygeal.

The ANTERIOR PRIMARY RAMI decrease in size from above downwards. The upper four issue from the anterior sacral foramina, the 5th emerging between sacrum and coccyx. Each nerve receives a grey ramus from the sympathetic. The first and part of the 2nd and 3rd nerves enter the sacral plexus, whilst the 4th and 5th enter the coccygeal plexus. Pelvic parasympathetic branches issue from the 2nd and 3rd (or 3rd and 4th) sacral nerves.

The SACRAL PLEXUS is formed by the lumbo-sacral trunk (4th and 5th lumbar), anterior primary rami of the 1st and part of the 2nd and 3rd sacral nerves. Lies on anterior surface of piriformis, behind the internal iliac (hypogastric) arteries and the rectum, and behind the pelvic fascia.

Branches

Muscular : To piriformis, from 1st and 2nd sacral.

Nerve to obturator internus : To obturator internus and gemellus superior, from 5th lumbar, 1st and 2nd sacral, emerges from pelvis through greater sciatic foramen, winds over ischial spine lateral to the internal pudendal artery, passes in through lesser sciatic foramen to medial surface of muscle, having first supplied superior gemellus.

Nerve to quadratus femoris : To quadratus femoris

and gemellus inferior, given off from lumbo-sacral cord and 1st sacral, passes on bone anterior to gemelli and obturator internus tendon to anterior surface of quadratus, giving on its way a branch to gemellus inferior and an articular branch to the hip-joint.

Superior gluteal : From lumbo-sacral trunk (L. 4 and 5) and 1st sacral; passes out of greater sciatic foramen, above the piriformis, with the superior gluteal vessels; divides into a *superior* branch, which passes between the two smaller glutei, supplying the medius, and an *inferior* branch, supplying the gluteus minimus and the tensor fasciæ latae.

Inferior gluteal : From the 5th lumbar, 1st and 2nd sacral nerves; passes out of pelvis below the piriformis, at the lower border of which it runs backwards, and, dividing into numerous branches, enters deep surface of gluteus maximus towards its medial attachment.

Posterior cutaneous nerve of thigh : Comes off from 2nd and 3rd sacral nerves; a cutaneous nerve to lower part of buttock, perineum, and back of thigh. It passes below the piriformis with the inferior gluteal artery, and runs beneath the gluteus maximus, and below this down the back of the thigh beneath the fascia lata, which it pierces in the popliteal space.

Branches

Perineal : To skin of upper and medial side of thigh; one of its larger branches turns medially over hamstrings, supplies scrotum, and joins the lateral scrotal branch of pudendal.

Gluteal : Wind round gluteus maximus; supply the skin over lower part of buttock.

Femoral : To skin of thigh, popliteal region, and upper part of calf of leg.

Perforating cutaneous : From back of 2nd and 3rd sacral; perforates sacro-tuberous ligament and lower border of gluteus maximus, supplies skin over lower part of buttock.

Sciatic : It is derived from the lumbo-sacral trunk, the 1st, 2nd, and 3rd sacral nerves; the largest nerve in the body, and is the main continuation of the sacral plexus, lying in pelvis on piriformis. It passes out of

pelvis below the piriformis, and between the tuberosity of ischium and greater trochanter, resting in turn upon the ischium, obturator internus, quadratus femoris, and adductor magnus. It enters thigh deep to hamstrings, and is accompanied by the inferior gluteal artery, which supplies a branch to its substance (companion artery of sciatic nerve). At a variable distance between the sacral plexus and lower part of the thigh, but generally about the middle of the thigh, the nerve bifurcates into tibial (medial popliteal) and common peroneal (lateral popliteal). In cases of division within the pelvis the lateral popliteal nerve pierces piriformis. Medial popliteal nerve is derived from all five nerves (L. 4, 5 and S. 1, 2, 3), anterior divisions; lateral popliteal from posterior divisions of L. 4, 5 and S. 1 and 2. They are nerves of flexor and extensor compartments respectively.

BRANCHES OF THE TRUNK

MUSCULAR: Given off under biceps to semimembranosus, semitendinosus, both heads of biceps femoris, and to the medial (*ischial*) part of adductor magnus. Branch to short head of biceps is derived from lateral popliteal, all the remainder from medial popliteal component of sciatic nerve.

TIBIAL (MEDIAL POPLITEAL): Larger terminal branch, passes along middle of popliteal space to lower border of popliteus, where it formerly took the name of *posterior tibial*, it is at first superficial and lateral to the artery, but at the lower end of the space, under the gastrocnemius, crosses to the medial side.

Branches

Articular (3): One accompanies each of the medial superior and inferior genicular arteries, the third the middle genicular.

Muscular : To the *gastrocnemius*, one for each head, the lateral one supplying also the *plantaris*. To the *soleus* and to the *popliteus*; the nerve to the latter turns round lower border of muscle and enters it upon its anterior surface.

Sural : Passes down leg superficially between two heads of the gastrocnemius, pierces the deep fascia about middle of leg, there being joined by the *lateral sural branch* of the common peroneal; it then follows the course of the short saphenous vein round the lateral malleolus, and supplies skin of lateral side of foot and little toe, communicating with the superficial (musculo-cutaneous) on the dorsum of the foot.

Tibial (*Posterior tibial*—continuation of medial popliteal) : Begins at the lower border of the popliteus, and runs with the posterior tibial vessels (p. 176) *on the back of the deep muscles* to interval between the medial malleolus and heel, where it divides into lateral and medial plantar. It is at first medial to the artery, but afterwards crosses to the lateral side.

Branches

Muscular : To soleus, tibialis posterior, flexor digitorum longus, and flexor hallucis longus, the latter accompanying the peroneal artery.

Medial calcanean : Pierces flexor retinaculum, to supply skin of heel and medial side of sole of foot.

Medial plantar : Larger terminal branch of the tibial; accompanies medial plantar artery along medial side of foot, the larger nerve thus accompanies the smaller artery. Corresponds in distribution to median nerve of hand. It passes between the abductor hallucis and flexor digitorum brevis to divide opposite the bases of the metatarsal bones into four branches, the most lateral of which communicates with the lateral plantar.

Branches

Cutaneous : To medial side of sole.

Muscular : To abductor hallucis and flexor digitorum brevis.

Articular : To tarsal and metatarsal articulations.

Plantar digital (4) : The 1st supplies medial border of 1st toe and the flexor hallucis brevis, the 2nd supplies the adjacent sides of the 1st and 2nd toes and the 1st lumbrical, the 3rd supplies the adjacent

sides of the 2nd and 3rd toes, and the 4th supplies the adjacent sides of the 3rd and 4th toes and joins a branch from the lateral plantar.

Lateral plantar : Corresponds in distribution to ulnar nerve in hand. Passes across to lateral side of foot with lateral plantar artery, supplying on its way lateral side of sole, the abductor digiti minimi and flexor digitorum accessorius; at the lateral border of the latter muscle it divides into two branches:

Superficial : Which divides into two plantar digital nerves, one supplying the lateral side of the little toe, the flexor digiti minimi brevis, and the two interossei of the 4th space; the other supplies the adjacent sides of the 4th and 5th toes and communicates with the medial plantar.

Deep or muscular : Accompanies deep part of plantar artery, supplying adductor hallucis (oblique and transverse heads), three lateral lumbricals and interossei of three medial spaces

COMMON PERONEAL (LATERAL POPLITEAL)

Passes along the popliteal space under cover of and medial to biceps tendon, then over lateral head of gastrocnemius to the fibula; winds forwards round the neck of that bone and pierces the peroneus longus, and in that muscle divides into deep peroneal (anterior tibial) and superficial peroneal (musculo-cutaneous) nerves.

Branches

Articular (2) : Generally given off together, accompany lateral superior and inferior genicular arteries.

Lateral cutaneous : Supply skin of back and lateral side of leg in upper third.

Lateral sural (*Sural communicating* : Arises close to head of fibula and joins the sural of posterior tibial.

Deep peroneal (*Anterior tibial*) : Passes to front of

interosseous membrane by piercing extensor digitorum longus to reach lateral side of anterior tibial artery, with which it descends on interosseous membrane to the ankle-joint, where it bifurcates into a medial and lateral branch; it lies in middle $\frac{1}{3}$ of leg, in front of artery, and in lowest $\frac{1}{3}$, again lateral to it.

Branches

Recurrent articular : A branch to knee, which accompanies anterior tibial recurrent artery to joint.

Muscular : To tibialis anterior, extensor digitorum longus, peroneus tertius, and extensor hallucis longus

Lateral : Passes laterally beneath the extensor digitorum brevis; supplies the extensor brevis, and the articulations of the tarsus and metatarsus.

Medial : Accompanies dorsalis pedis artery to 1st interosseous space, lying lateral to it; supplies adjacent sides of 1st and 2nd toes; communicating with the superficial peroneal (musculo-cutaneous).

Superficial peroneal (Musculo-cutaneous) : Supplies peroneus longus and brevis, and cutaneous branches to dorsum of foot. It passes down between peronei and the long extensor of toes, piercing deep fascia at lower $\frac{1}{3}$ of leg.

Branches

Muscular : To peroneus longus and peroneus brevis.

Cutaneous : To lower part of leg.

Medial : Passes over ankle to medial side of 1st toe and adjacent sides of 2nd and 3rd toes; communicates with saphenous and deep peroneal (anterior tibial) nerves.

Lateral : Supplies adjoining sides of 3rd, 4th, and 5th toes; communicates with sural.

Pudendal : Comes off from the 2nd, 3rd, and 4th sacral nerves, passes out of greater sciatic foramen between piriformis and coccygeus, medial to sciatic

nerve, winds over sacro-spinous ligament medial to internal pudendal artery, and re-enters pelvis through the lesser foramen lying on medial side of internal pudendal artery; it then enters, with accompanying vessels, the pudendal canal in the obturator fascia on the lateral wall of the ischio-rectal fossa and divides into its three branches.

Branches

1. *Inferior rectal (hæmorrhoidal)* : Arches over ischio-rectal fossa to supply external sphincter, skin of anus; communicates with perineal of posterior cutaneous nerve of thigh and scrotal nerves.

2. *Perineal* : Largest terminal branch, accompanies artery, and divides into:

Scrotal or labial, two in number: the medial passes with scrotal artery either under or over the superficial transversus perinei to supply the scrotum; the lateral gives a branch to the anus, and, piercing the membranous layer of the superficial fascia, supplies the scrotum, joining the perineal of posterior cutaneous.

Muscular branches supply transversus perinei, ischio-cavernosus, bulbo-cavernosus (bulbo-spongiosus), sphincter urethræ, external sphincter and levator ani.

Nerve to bulb : Pierces bulbo-cavernosus (bulbo-spongiosus) and supplies bulb.

3. *Dorsal nerve of the penis* : Accompanies internal pudendal artery deep to perineal membrane lying lateral to the artery, pierces the perineal membrane and the suspensory ligament to reach dorsum of penis, along which it runs as far as the glans, gives off many branches to supply the organ, and joins branches of the sympathetic. In the female this nerve is distributed to the clitoris.

COCCYGEAL PLEXUS

Perineal branch of fourth sacral: Leaves pelvis between coccygeus and levator ani, supplying each

on its pelvic surface. In pelvis supplies external sphincter (superficialis), peri-anal skin and dartos muscle.

The anterior ramus of the 5th sacral emerges from sacral hiatus, and turning forward pierces coccygeus. It is joined by a small branch from the 4th sacral and anterior ramus of coccygeal nerve to form coccygeal plexus; from this the coccygeal nerve arises. It pierces the sacro-tuberous ligament to supply the skin over the coccyx.

DERMATOMES

The skin of the trunk is supplied segmentally by the intercostal nerves. In the limbs a similar segmental supply is furnished by the cutaneous nerves. The area of skin supplied by one spinal nerve is called a *dermatome*. The arrangement of the limb dermatomes is shown in Fig. 55. Note that at the anterior and posterior axial lines discontinuous dermatomes lie in contact with each other, the dermatome of the central root of each plexus lying at the extremity of the limb (C. 7 for hand, S. 1 for foot). Such peripheral dermatomes on the limb have no contact with skin of body wall. Adjacent dermatomes overlap considerably (not shown in Fig. 55) but there is no overlap across the axial lines.

NOTE.—Knowledge of dermatomes remains uncertain; any chart (as Fig. 55) is only approximate

THE AUTONOMIC NERVOUS SYSTEM

This is the visceral (splanchnic) part of the nervous system and comprises the nerve-supply to the viscera, glands and bloodvessels, and to non-skeletal muscle in general throughout the body. It consists of a *sympathetic* system and a *parasympathetic* system. All the efferent fibres of the sympathetic arise in the thoracic and upper lumbar parts of the spinal cord; the parasympathetic fibres are incorporated in certain of the cranial and sacral nerves. All the efferent

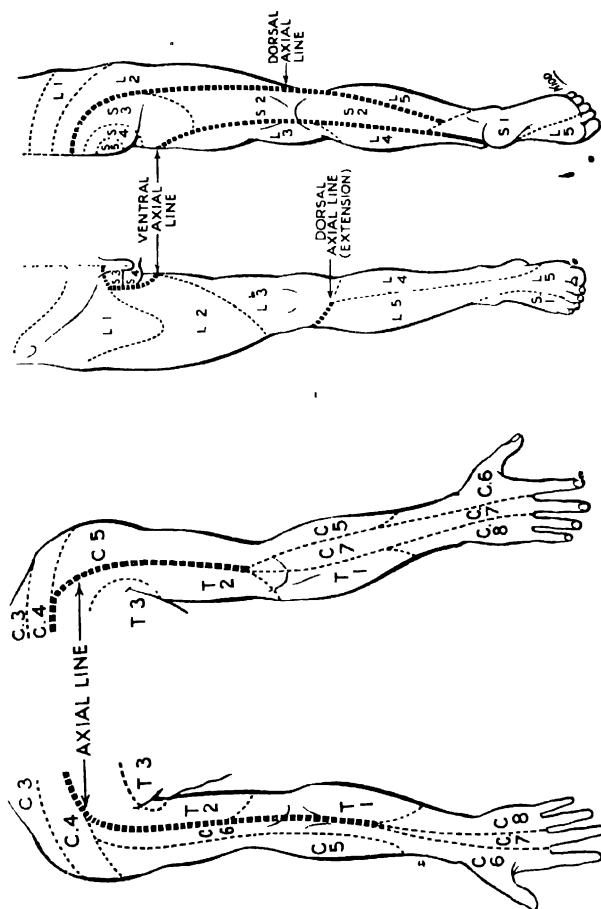


FIG. 55.—THE ARRANGEMENT OF THE DERMATOMES OF THE LIMBS (approximate).

The *pre-ganglionic fibres*, which are medullated, pursue a course of variable length within the nerve, spinal or cranial, as the case may be, with which they are associated, and, leaving the nerve, make their way to the particular ganglion to which they are destined.

In the case of the spinal nerves, the pre-ganglionic fibres constitute the *white rami communicantes*. They arise from cells in the lateral column of the c.c.d., and leave through the anterior nerve roots from the first thoracic nerve to the 2nd lumbar nerve inclusive. (Figs. 56, 57).

The *post-ganglionic fibres* conduct the nervous impulse to its final destination, and usually they are non-medullated. In the case of the spinal nerves, they constitute the *grey rami communicantes*. The latter are reincorporated in the spinal nerve, and are thus distributed with it. Other post-ganglionic fibres make their way to the viscera either directly or by way of the blood vessels.

The *ganglia* of the autonomic system form three groups:—

- (1) Lateral ganglia of the sympathetic trunk.
- (2) Collateral ganglia or plexuses.
- (3) Terminal or distal ganglia in the walls of the structures supplied.

The sympathetic pre-ganglionic (connector) fibres go to cell stations in either the lateral or collateral ganglia, while the parasympathetic pre-ganglionic fibres usually have theirs in the terminal ganglia.

The *lateral ganglia* lie along the sympathetic trunks which are placed one on each side of the vertebral column, extending from the level of the second cervical vertebra downwards. Each ganglionic chain comprises three cervical, eleven thoracic, four lumbar and four sacral ganglia.

The ganglia from the first thoracic to the 2nd lumbar receive from the corresponding spinal nerves white communicating branches. The only remaining white communicating branches are those given off

from the second and third sacral nerves, and these belong to the parasympathetic. To every spinal nerve, without exception, there is given off a grey communicating branch. The post-ganglionic fibres which constitute this branch are thus distributed with the spinal nerve. Numerous pre-ganglionic fibres, having their cell stations in the collateral ganglia, pass without interruption through the lateral ganglia, and among these are the splanchnic nerves.

From the cervical ganglia, which receive their white branches from the first and second thoracic nerves, grey branches are given off to the cervical nerves. Post-ganglionic fibres also proceed to the dilator pupillæ and to the unstriated muscle in the upper eyelid and at the back of the orbit; to the buccal and salivary and lachrymal glands by way of the plexuses along the carotid vessels and their branches.

The *collateral ganglia* comprise various plexuses: in the thorax the cardiac and pulmonary and œsophageal; in the abdomen, the celiac, aortic and hypogastric plexuses.

The *terminal ganglia* lie in the muscular walls of certain of the viscera. A summary of the distribution of the sympathetic and parasympathetic is given in the appended scheme (p. 290).

The cell stations of the parasympathetic fibres contained in the oculo-motor, facial, and glossopharyngeal nerves are found in the cranial autonomic ganglia.

CRANIAL AUTONOMIC GANGLIA

In parasympathetic system, excitor cells usually scattered in walls of viscus. In head they are grouped into four ganglia, ciliary, sphenopalatine, submandibular and otic. *All contain parasympathetic cells only.* In addition to white parasympathetic root, each has sensory and sympathetic roots. Otic, in addition, has motor root for tensor tympani and tensor palati muscles. All these fibres pass through the ganglia *without relay*. The study of the four

* THE ARRANGEMENT AND DISTRIBUTION

	<i>Origin.</i>	<i>Nerves carrying Pre-ganglionic Fibres.</i>
Cranial parasympathetic	Mid-brain. Medulla.	Oculo-motor. Nervus intermedius. Glosso-pharyngeal. Vagus
Sympathetic	Thoraco-lumbar cord.	First thoracic nerve to second lumbar inclusive.
"		
Sacral parasympathetic	Sacral cord.	Second and third or third and fourth sacral nerves

* From Grant Massie's "Surgical Anatomy," with the author's kind permission.

OF THE AUTONOMIC NERVOUS SYSTEM

<i>Cell Station and Synapse.</i>	<i>Distribution</i>	<i>Effect of Stimulation.</i>
Ciliary ganglion. Spheno-palatine, otic, submandibular and sublingual ganglia. Mostly in the viscera supplied.	Constrictor pupillæ and ciliary muscles. Salivary glands. Heart and bronchi. Alimentary canal, liver, gall-bladder and pancreas.	Contraction of the pupil and accommodation. Increased flow of saliva. Slowing of the heart beat. Increased peristalsis. Relaxation of sphincters.
Lateral ganglia of the sympathetic trunk, also collateral ganglia in the cardiac, pulmonary, œsophageal, cœliac, aortic, mesenteric and hypogastric plexuses	Dilator pupillæ muscle. Sweat glands, hairs and blood-vessels of the body wall and skin. Heart Visceral blood-vessels. Alimentary canal and its associated glands of secretion	Dilatation of the pupil Secretion of sweat, erection of hairs. Acceleration of the heart beat. Inhibition of peristalsis. Contraction of the sphincters of the bladder and rectum.
Terminal for the most part in the viscera supplied	Bladder. Rectum. Genitalia. (i.e., derivatives of cloaca.)	Emptying of the bladder and rectum, their sphincters being at the same time relaxed.

ganglia will be simplified if no nerve fibre is ever thought of without visualising the site of its cell body (Fig. 58). In all cases sensory root has cell body in trigeminal ganglion, sympathetic root has cell body

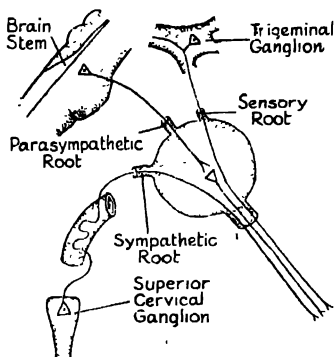


FIG. 58.—BASIC PLAN OF THE CRANIAL AUTONOMIC GANGLIA.

in superior cervical ganglion, and parasympathetic cell bodies vary with the ganglion (see accounts of individual ganglia).

THE SYMPATHETIC SYSTEM

The sympathetic fibres arise in the lateral horn of the grey matter of the spinal cord, and leave the cord in the anterior nerve-roots. They pass from the nerve to a sympathetic ganglion as a *white (unmyelinated) ramus communicans*; after synapse they leave the ganglion either to be distributed independently, or to rejoin the spinal nerve as a *grey ramus communicans*.

THE SYMPATHETIC TRUNKS

two in number, extend the whole length of the vertebral column. They consist of ganglia, united by

intervening cords, and are placed partly in front and partly by the side of the vertebræ. Above they are connected with two plexuses entering the cranium, and below they join together in front of the coccyx. The parts of the cords are named according to the region they occupy—viz. cervical, thoracic, lumbar, and sacral. The cervical portion has three ganglia, whilst in the rest of its extent each cord contains ganglia one less in number than the vertebræ.

From each ganglion is given off to the *anterior primary ramus* of the corresponding spinal nerve at least one (grey) communicating branch; the anterior primary rami of the thoracic and first two lumbar nerves give off white medullated branches to the corresponding ganglia. The inter-ganglionic cords are composed of white fibres, the former being continuous with the filaments from the spinal nerves.

THE CERVICAL PART of the sympathetic trunk lies behind the carotid sheath, adherent to the prevertebral fascia, and contains three ganglia.

I. THE SUPERIOR CERVICAL GANGLION, a flattened mass about 1 inch long, lies on the prevertebral fascia behind the carotid sheath, opposite the 2nd and 3rd cervical vertebræ.

Branches

Communicating : With the anterior primary rami of 1st, 2nd, 3rd, and 4th cervical nerves, with the superior and inferior ganglia of the vagus, with the hypoglossal, with the inferior ganglion of the glossopharyngeal.

Pharyngeal nerves and plexus : The pharyngeal nerves are given off from the front of the superior cervical ganglion, and pass forwards and downwards, to join with branches from the vagus and glossopharyngeal nerves to form the pharyngeal plexus, which lies on the middle constrictor muscle.

The superior cardiac nerves : The *right superior cardiac nerve* comes off by two roots from the superior cervical ganglion. It passes downwards behind the carotid sheath, but in front of the inferior thyroid

artery and recurrent laryngeal nerve. It then goes either behind or in front of the subclavian artery, and, coursing along the innominate, ends in the deep cardiac plexus. In the middle of the neck it communicates with the external laryngeal, lower down with the superior cardiac branches of the vagus, in the thorax with the recurrent laryngeal, and with other sympathetic branches in its whole course.

The *left superior cardiac nerve* has the same connections in the neck as the right nerve. On entering the thorax it passes along left common carotid artery, and, crossing the arch of the aorta, joins the *superficial cardiac plexus*.

Branches to vessels : Filaments are given to the external carotid artery, which are prolonged to its branches.

Ascending or carotid branch lies behind internal carotid artery, enters carotid canal, and divides into:—

- (a) *Lateral division* : Distributed to internal carotid; communicates with tympanic branch of glosso-pharyngeal, and forms the carotid plexus
- (b) *Medial division* : Distributed over internal carotid artery, thus communicating with the lateral division, and prolonged to form the cavernous plexus.

The **carotid plexus** lies on the lateral side of the internal carotid artery at its 2nd bend.

Branches

Communicating : To the abducent nerve and trigeminal ganglion.

The *deep petrosal nerve* passes from the plexus through the hiatus, to join the greater superficial petrosal nerve in foramen lacerum, and form the nerve of the pterygoid canal.

The *carotico-tympanic nerves* pass backwards in small canals in the processus cochleariformis, to join the tympanic plexus.

The **cavernous plexus** lies below and to the medial side of last bend of the internal carotid artery.

Branches

Communicating. To the oculo-motor, trochlear, and ophthalmic division of trigeminal nerve.

Ganglionic: The sympathetic root of the ciliary ganglion passes into the orbit. It is generally joined to the sensory root from the naso-ciliary of the ophthalmic. Vaso-constrictor.

Long ciliary: Enter orbit with naso-ciliary nerve, motor to dilator pupillæ muscle (trigeminal fibres of long ciliary nerves sensory to iris and ciliary body).

2. The MIDDLE CERVICAL GANGLION usually lies on the inferior thyroid artery, opposite the 6th cervical vertebra.

Branches

Communicating: To the anterior primary rami of the 5th and 6th cervical nerves.

Thyroid: To the thyroid gland, communicating with external and recurrent laryngeal nerves, and with the cardiac nerve from the superior cervical ganglion. Distributed along inferior thyroid artery to larynx and pharynx below level of vocal cords and, in continuity, to whole trachea and œsophagus down to lung roots.

Middle or great cardiac nerve: On the *right* side passes in front or behind subclavian artery to the front of the trachea, and joins the deep cardiac plexus. Communicates in the neck with the superior cardiac and recurrent laryngeal nerves. On the *left* side it lies between the left carotid and left subclavian arteries, and joins the deep cardiac plexus.

3. The INFERIOR CERVICAL GANGLION lies between the transverse process of the 7th cervical and the neck of the 1st rib, behind the vertebral artery, medial to the costo-cervical trunk.

Branches

Communicating: To the anterior primary rami of the 7th and 8th cervical nerves.

Inferior cardiac nerve: Passes behind the subclavian artery, joins recurrent laryngeal, and enters the deep cardiac plexus.

Branches to vessels: Branches are given to form a plexus round the vertebral artery.

Stellate Ganglion: When present lies over neck of first rib. Is a fusion of inferior cervical with first thoracic ganglion.

ANSA SUBCLAVIA: Formed of fibres which pass in front of subclavian artery; main part of cervical sympathetic trunk passes into neck behind that vessel.

The **THORACIC PART** of the sympathetic trunk lies by the side of the vertebræ over the necks of the ribs near their heads. Bound down by parietal pleura anterior to intercostal neuro-vascular bundles. The ganglia are eleven (usually) or twelve in number, and each has grey and white rami with the corresponding intercostal nerve.

Branches of the upper 6 ganglia are given off to the thoracic aorta, vertebræ, ligaments, and from the third and fourth to the œsophageal and pulmonary plexuses.

Branches from the lower 6 or 7 ganglia :

The **greater splanchnic nerve** : Formed by the union of branches from the 5th, 6th, 7th, 8th and 9th ganglia. It passes medially over the bodies of the vertebræ, perforates the crus of the diaphragm, and ends in the cœliac ganglion.

The **lesser splanchnic nerve** comes from the 10th and 11th ganglia, passes with the great splanchnic nerve, and ends in the cœliac ganglion.

The **lowest splanchnic nerve** comes from the 12th ganglion (if present). It pierces the crus of the diaphragm, and ends in the renal plexus, and partly in the cœliac plexus.

The **LUMBAR PART** of the gangliated cord lies, nearer the middle line than the thoracic, on the bodies of the vertebræ at the medial margin of psoas. Thoracic cord reaches lumbar cord by passing behind medial arcuate ligament.

Upper two ganglia receive white rami, all give grey rami to corresponding lumbar nerves; rami pass under fibrous arches of psoas. The ganglia give off branches to the aorta, and other branches to form the hypogastric plexus.

The **SACRAL PART** of the sympathetic trunk lies to the medial side of the anterior sacral foramina, and is

united with its opposite fellow at the lower end of the sacrum by a cord, in the middle of which there is sometimes found a *coccygeal ganglion* or ganglion impar.

Branches are given from the ganglia to sacral nerves and the pelvic plexus.

THE PREVERTEBRAL (COLLATERAL) PLEXUSES OF THE SYMPATHETIC

The CARDIAC PLEXUS lies against the aorta and pulmonary artery. It is divided into two parts, *superficial* and *deep*.

The **superficial cardiac plexus** lies in the concavity of the arch of the aorta in front of the ligamentum arteriosum. It is composed of the left superior cardiac nerve of the sympathetic, the inferior cervical cardiac of the left vagus nerve, and branches from the deep plexus. The plexus gives branches to the anterior pulmonary plexus of the left side, and ends in the right coronary plexus which accompanies the right coronary artery.

The **deep cardiac plexus** lies between the arch of the aorta and the trachea. It consists of right and left halves which freely communicate. The right half lies above the right branch of the pulmonary artery; the left half lies on the left of the trachea, close to the ligamentum arteriosum.

Afferent branches :

- (a) All the cardiac branches from the cervical ganglia of the sympathetic, except the left superior nerve.
- (b) All the cardiac branches of vagi and recurrent laryngeals, except the inferior cervical cardiac of the left vagus.

Efferent branches of the right side join the superficial cardiac plexus to form the right coronary plexus, and others are distributed to the right atrium.

Efferent branches of the left side mostly end in the left coronary plexus, which accompanies the left coronary artery, and in the superficial cardiac plexus

PULMONARY PLEXUS (p. 296).

ŒSOPHAGEAL PLEXUS (p. 296).

The **CÆLIAC PLEXUS** is the largest prevertebral plexus. It lies behind the pancreas and inferior vena cava, in front of the aorta and crura of the diaphragm. It surrounds the origin of the cœliac artery, extending laterally to the suprarenal glands. It receives the greater and lesser splanchnic nerves and part of the right vagus. It contains several ganglia, and branches are given off from it to accompany the bloodvessels to the viscera, and to form secondary plexuses on these arteries.

The **cœliac ganglia**, one in each half of the cœliac plexus, lie on the medial side of the suprarenal glands, the right one lying behind inferior vena cava. The greater splanchnic nerve enters its upper end.

The **phrenic plexus** accompanies the arteries to the diaphragm. On the right side near the suprarenal gland is the *phrenic ganglion*, connecting together the phrenic nerves of the spinal and sympathetic systems.

The **suprarenal plexus** is derived from the cœliac plexus and the lateral part of the cœliac ganglion. It is joined by branches of one of the splanchnic nerves.

The **renal plexus** is derived from the cœliac ganglion and partly from the cœliac and aortic plexuses, and receives the lowest splanchnic nerve. It lies along the renal artery, and contains numerous small ganglia.

The **testicular plexus** comes off from the renal and aortic plexuses.

The **superior gastric plexus** accompanies left gastric artery along the lesser curvature of the stomach, communicating with the vagus nerves.

The **hepatic plexus** accompanies hepatic artery into the substance of the liver. Communicates with the left vagus, and the right suprarenal plexus. Gives off the *cystic*, *pyloric*, *right gastro-epiploic* and *pancreatico-duodenal* plexuses.

The **splenic plexus** accompanies splenic artery to the spleen, and is joined by the right vagus. It gives off the *left gastro-epiploic* and *pancreatic* plexuses.

The **superior mesenteric plexus** accompanies superior mesenteric artery.

The **aortic plexus** lies on the anterior surface of the abdominal aorta. It gives off the *inferior mesenteric* and part of the *testicular* plexuses. It ends in the hypogastric plexus.

The **HYPOGASTRIC PLEXUS** lies over sacral promontory between the two common iliac arteries; it is formed by the termination of the aortic plexus, together with branches from the lumbar ganglia (the so-called *presacral nerves*). It divides below into two parts, which form the pelvic plexuses.

The **PELVIC PLEXUSES**: Two in number. Each is composed of a division of the hypogastric plexus joined with branches from the sacral ganglia and from the 2nd and 3rd sacral nerves (parasympathetic).

The following plexuses are derived from the pelvic plexuses:

The **rectal plexus** to the rectum and anal canal.

The **vesical plexus** to the bladder, with secondary plexuses in the male to the vas deferens and to the seminal vesicles

The **prostatic plexus** to the prostate gland, giving off the *cavernous nerves* of the penis.

[The **vaginal plexus** to the vagina.

The **uterine plexus** accompanying the uterine artery to the uterus]

CHAPTER EIGHT

The Sense Organs

THE EAR

The ear is composed of three parts—external, middle, and internal.

THE EXTERNAL EAR

The **external ear** consists of the auricle and the *external auditory meatus*.

• The **auricle** (*pinna*) is a plate of yellow elastic cartilage covered with skin, and attached to the commencement of the meatus; it has numerous ridges and depressions.

For the muscles of the auricle see p 47.

The **external auditory meatus** reaches from the bottom of the concha to the tympanic membrane; it is $1\frac{1}{2}$ inches long. It is arched slightly upwards, and is directed forwards and medially; it is formed partly by cartilage and partly by bone. The lateral or cartilaginous part is continuous with the auricle, and is about $\frac{1}{2}$ inch long. The cartilage does not form a complete tube, being deficient at the upper and back part, the interval being filled by fibrous tissue. The medial or osseous part is longer than the cartilaginous; at its medial end there is a groove round the sides and floor for the insertion of the tympanic membrane. The external meatus is lined by skin, in which are hairs and ceruminous glands, which latter secrete the ear-wax.

THE MIDDLE EAR OR TYMPANUM
(Fig. 59)

The middle ear is contained in the temporal bone. It communicates with the pharynx by the auditory, or pharyngo-tympanic (Eustachian) tube, and is traversed by a chain of bones, which transmit sound vibrations from the tympanic membrane to the internal ear.

The **tympanic cavity** is bounded *laterally* by the meatus and tympanic membrane, *medially* by the lateral wall of the internal ear; its upper part *epitympanic (recess)* communicates posteriorly with the tympanic antrum by the *aditus*.

The **roof** is formed by a thin plate of bone (*tegmen tympani*) separating the middle ear from the middle fossa of the skull.

The **floor** is formed by the roof of the jugular fossa.

The **lateral wall** is formed by the tympanic membrane and the bone around it; the following fissures are seen:

The *squamo-tympanic fissure*. Through which the anterior ligament of the malleus and anterior tympanic branch of maxillary artery pass.

Aperture of the posterior canaliculus for chorda tympani: Leading to a canal which opens into the canal for facial nerve.

Aperture of the anterior canaliculus for chorda tympani: Leading to the canal for chorda tympani, through which the nerve passes to join the lingual.

The **medial wall** presents the following:

The *fenestra vestibuli (foramen ovale)*: Leading into the vestibule, closed by a ligament and the base of the stapes.

The *promontory*: Placed below the fenestra vestibuli; formed by the projection of the first turn of the cochlea.

The *fenestra cochleæ (foramen rotundum)* lies at the bottom of a funnel-shaped depression behind the promontory. It is closed by a membrane, the *secondary tympanic membrane*, which covers an aperture in the bone leading to the scala tympani of the cochlea.

The *prominence of the facial canal*, for the facial nerve, running backwards along the upper part of the medial wall, and then turning downwards in the medial wall of the aditus.

The **posterior wall** presents above, the large aperture (*aditus*) to the *tympanic antrum* and below:

The *pyramid*, which is placed just behind the fenestra vestibuli; it contains the stapedius muscle, the tendon of which projects through the apex.

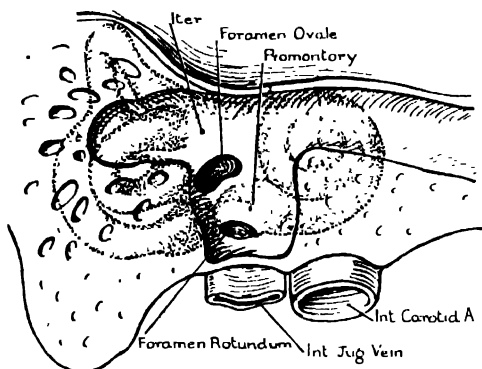


FIG. 59.—RIGHT MIDDLE EAR VIEWED FROM LATERAL ASPECT.

The vestibule, with semicircular canals behind and cochlea in front, are projected as though they could be seen through the middle ear.

The **anterior wall** shows the following:

The *canal for the tensor tympani*, opening just anteriorly to the fenestra vestibuli.

The *auditory*, or *pharyngo-tympanic (Eustachian) tube* leads into the pharynx. Part is elastic cartilage and part bone. The medial or cartilaginous part is trumpet-shaped, and terminates in an oval opening at the side and upper part of the naso-pharynx. The osseous portion is placed along the angle of union of the squamous and petrous portions of the temporal bone, and is about $\frac{1}{4}$ inch long. Below this a thin plate of

bone separates the tympanum from the carotid canal.

The *processus cochleariformis* : A process of bone lying between and separating the canal for the tensor tympani and the auditory (pharyngo-tympanic) tube.

The **tympanic membrane** is the membrane which separates the external and middle ears. It is inserted into the groove in the osseous portion of the external meatus, and is placed obliquely across the opening, forming with the floor of the meatus an angle of 55 degrees. It bulges into the middle ear, so that its lateral surface is concave. Attached to its medial surface is the malleus.

The upper part of the membrane is thin and loose, and known as the *pars flaccida*.

The **ossicles of the tympanum** are:

1. The malleus.
2. The incus.
3. The stapes.

The **malleus**, or hammer, consists of:

The *head* : The thickened upper part, presenting on the posterior surface a facet for articulation with the body of the incus.

The *neck* : a constriction below the head.

The *handle* : A long tapering process passing downward, and attached laterally to the tympanic membrane.

The *anterior process* : A slender spicule passing from the neck downwards and forwards towards the petro-tympanic fissure.

The *lateral process* : Arises from the root of the handle and projects laterally to be attached to the tympanic membrane by the anterior and posterior malleolar folds, which bound the flaccid part of the membrane.

The **incus**, or anvil, consists of:

The *body* : Articulating in front by a saddle-shaped facet with the head of the malleus.

The *short process* : Attached to the margin of the aditus.

The *long process* : Passes downwards, behind and parallel to the handle of the malleus. The tip projects

medially, and ends in the *lentiform nodule*, which articulates with the head of the stapes.

The **stapes** closely resembles a stirrup. It consists of:

The *head* : Looking laterally, and articulating with the lentiform nodule of the incus.

The *base* : Fixed to the membrane closing the fenestra vestibuli.

The *limbs* : Arising from a constricted part, the neck, pass medially to the extremities of the base. The anterior limb is shorter and straighter than the posterior.

The **ligaments** unite the chain of bone to the adjacent walls of the tympanum. They are:

The *anterior ligament of the malleus* : Passing between the root of the anterior process and the petro-tympanic fissure.

The *lateral ligament of the malleus* : Passing between the lateral process and the posterior malleolar fold.

The *superior ligament of the malleus* : Passing between the head of the malleus and the roof of the tympanum.

The *posterior ligament of the incus* : Passing between the short process and the posterior wall of the tympanum.

The *annular ligament of the stapes* connects the base of the stapes with the edge of the fenestra vestibuli.

In addition capsular ligaments of *elastic tissue* surround the synovial joints of malleus with incus and incus with stapes.

The **muscles** :

The *tensor tympani* arises from the cartilage of the auditory (pharyngo-tympanic) tube, and from the bony canal in which it lies. The tendon turns round the end of the processus cochleariformis, and is inserted into the medial border of the handle of the malleus, near its root. Supplied via otic ganglion from mandibular division of trigeminal nerve.

The *stapedius* is lodged in the pyramid, from the apex of which its tendon issues to be inserted in the

posterior part of the neck of the stapes. Supplied by facial nerve.

Action of each is to damp down over-vibration of membrane and ossicles.

The **tympanic (mastoid) antrum** is a large recess behind and above the tympanum, with which it is connected by the large opening (*aditus*) before mentioned on the upper part of the posterior tympanic wall; it is developed with the tympanum and lined by a continuation of its mucous membrane. Into it open the mastoid air-cells. It lies beneath the suprameatal triangle 15 mm. from the surface.

THE INTERNAL EAR OR LABYRINTH

Within the internal ear are the terminal ramifications of the eighth cranial nerve. The internal ear or labyrinth is divided into *bony* and *membranous* parts, the former enclosing the latter. Within the membranous labyrinth is a fluid, the *endolymph*; and outside, between the membranous and osseous labyrinths, is a fluid, the *perilymph*.

The **BONY LABYRINTH** consists of the vestibule, the semicircular canals, and the cochlea.

The **vestibule** is the central part of the labyrinth. Its lateral wall corresponds to the medial wall of the middle ear, and in it is the *fenestra vestibuli*, closed by the base of the stapes; on its medial wall is a depression, the *spherical recess*, perforated by several holes for the branches of the eighth nerve; behind this is a ridge, the *vestibular crest*; and still further back is the medial opening of the *aqueduct of the vestibule*, for transmission of the endolymphatic duct. On the roof is a depression, the *elliptical recess*. At the posterior part are the five openings of the *semicircular canals*, and at the anterior part is an opening which leads to the *scala vestibuli*.

The **semicircular canals** (organs of equilibrium) are three arched osseous canals placed above and behind the vestibule, opening into that chamber by five rounded apertures, two adjacent canals having a common opening. Each canal forms about two-thirds of a circle, and presents at one end a dilated

part, the *ampulla*. Two of the canals are vertical, and the third is horizontal.

The *anterior* (*superior*) canal is vertical, and placed transversely to the long axis of the petrous part of the temporal bone. The medial extremity joins the opening of the posterior canal.

The *posterior* canal is vertical in a plane at right angles to the former, its upper end being joined to the lower opening of the superior canal.

The *lateral* canal is the smallest of the three, and slopes 30 degrees upwards from horizontal just above the level of the fenestra vestibuli.

The *cochlea* (organ of hearing) is cone-shaped, with the base turned to the internal meatus, and the apex opposite the canal for the tensor tympani, and consists of a tapering spiral canal of $2\frac{1}{2}$ turns, around a bony axis or *modiolus*, the canal is divided into two *scalæ* by a partition of bone and membrane, the *spiral lamina*. The enclosed arched extremity of the cochlea is called the *cupola*, and the first turn of the canal bulging into the tympanum forms the promontory. The *osseus spiral lamina* ends at the apex of the cochlea in a small point, the *hamulus*, between which and the modiolus is a small opening, the *helicotrema*, by which the two *scalæ* communicate.

The *modiolus* is pierced by small canals for the passage of cochlear nerves, and one larger one, the *longitudinal canal of the modiolus*, passes from the base to the last half-turn of the cochlea. At the base of the lamina spiralis is a small canal, the *spiral canal of the modiolus*, which winds round the axis, and contains a spiral ganglionated cord, the *spiral ganglion* of cochlear nerve, analogous to posterior root ganglion of a spinal nerve.

The *scalæ* are known respectively as the *scala tympani* and the *scala vestibuli*.

The *scala tympani* is the lower one; it commences at the fenestra cochleæ. Near fenestra cochleæ is opening of *aqueduct of cochlea* which conveys perilymph to aperture in glosso-pharyngeal notch of petrous bone in jugular foramen, where it communicates with cerebro-spinal fluid.

The *scala vestibuli* commences at the cavity of the vestibule, and communicates at the apex of the modiolus with the *scala tympani* by the helicotrema. Each scala contains perilymph.

The MEMBRANOUS LABYRINTH consists of sacs containing fluid (endolymph). The ramifications of the auditory nerve are distributed on the wall. These membranous sacs complete the septum between the *scala tympani* and the *scala vestibuli*, besides enclosing a third space, the *duct of the cochlea*.

The **membranous vestibule** consists of two sacs, the *utricle* and the *sacculæ*.

The **utricle** or common sinus is larger than the *sacculæ*, and is situated in the posterior and upper part of the vestibule, being contained in the elliptical recess. The apertures of the membranous semicircular canals open in the posterior part. At the anterior part is a thickened spot, the *macula*, where the vestibular nerves enter. The interior contains, opposite the *macula*, attached to the wall, a small mass of calcareous grains, known as otoliths. Below there is a canal, which, joined to a similar tube from the *sacculæ*, extends along the aqueduct of the vestibule as the endolymphatic duct, and ends in a dilated pouch, the *endolymphatic sac*.

The **sacculæ** is smaller and rounder than the *utricle*, and lies in the spherical recess. Like the *utricle*, it contains a *macula* and a collection of otoliths. Below there is a small canal, *ductus reuniens*, which connects it with the duct of the cochlea.

The **semicircular ducts** are about one-third the size of the canals, except at the ampullæ, where each dilates nearly to fill the bony canal. Each duct is free on its concave aspect, the convexity being fixed to the osseous canal. On the part of the medial surface of the ampulla corresponding to the attachment to the bony canal is a transverse projection, the *ampullary crest*, in which some filaments of the vestibular nerve end.

The **membranous cochlea** fills the gap left by the osseous spiral lamina, separating *scalæ vestibuli* and *tympani*. It contains the *spiral organ*, to which

the cochlear nerve is chiefly distributed.

The osseous spiral lamina partly divides the spiral canal into the scala tympani and scala vestibuli, the latter being superior. The septum is completed by the *basilar lamina*, which is attached to the lateral free edge of the osseous spiral lamina, and passes laterally to the wall of the cochlea, where it is fixed to a thickening of the periosteum called the basilar crest.

The **duct of the cochlea** contains the spiral organ. (Do not confuse with *aqueduct* of the cochlea, a canal for perilymph in the petrous bone, p. 306). It lies lateral to the scala vestibuli, and is separated from it by the *vestibular membrane*, which passes from the lamina spiralis upwards and laterally to the roof of the scala. Thus a triangular piece is cut off, bounded medially by the vestibular membrane, laterally and above by the lateral wall of the cochlea, and below by the basilar lamina. The duct of the cochlea is connected below with the sacculæ by the *ductus reuniens*, and above it terminates in a blind cone-shaped extremity, partly bounding the helicotrema and fixed to the cupola. The part of the spiral lamina within the duct of the cochlea becomes thickened, and is called the *limbus*, and terminates in a concave border, the *hamulus of the spiral lamina*. The basilar lamina is attached to the lower margin of the hamulus.

The vestibulo-cochlear (auditory) nerve (see p. 253): The auditory nerve divides in the internal auditory meatus into two branches, which enter foramina at the bottom of the meatus, and are distributed to the cochlea and the vestibule.

The *posterior* or vestibular branch supplies:

- 1. The utricle.
- 2. The sacculæ.
- 3. The ampullæ of the semicircular canals.

The vestibular ganglion lies deep in the internal auditory meatus.

The *inferior* or cochlear branch is distributed to the cochlea

Nerves of the Cochlea : The branches of the auditory

nerve destined for the cochlea perforate a number of foramina at the bottom of a spiral groove, the *tractus spiralis foraminosus*, placed in the centre of the base of the cochlea. These foramina lead to small canals, which at first pass through the modiolus, and then radiate laterally between the bony layers of the spiral lamina, so passing to the spiral organ. In the centre of the tractus spiralis foraminosus is a larger foramen leading to the longitudinal canals of the modiolus, and transmitting nerve filaments for the last half-turn of the cochlea. Bipolar nerve cells lying in modiolus at base of spiral lamina constitute the *spiral ganglion*.

THE EYE' AND ITS APPENDAGES

THE APPENDAGES OF THE EYE

The **eyebrows** are two arched eminences, one over each orbit, consisting of thickened skin and muscles, surmounted by hairs.

The **eyelids** are two movable folds, an upper and a lower, the upper one being more movable, which by their closure protect the eye from injury. Blinking spreads a film of tears on the cornea and pumps away excessive tears. When the eyelids are open the angles of junction of the upper and lower lids are called respectively the lateral and the medial angle. In the medial angle the lids are separated by a small triangular area, the *lacus lacrimalis*, in which is seen a pink mass of connective tissue containing sebaceous glands, the *lacrimal caruncle*. This is separated from the eyeball by a vertical fold of conjunctiva, the *plica semilunaris*, a rudimentary third eyelid; opposite the lateral edge of the caruncle, on each lid, is the *lacrimal papilla*, which is pierced by the *punctum lacrimale*, the external opening of the lacrimal canaliculus.

Structure from without inwards: skin, areolar tissue, orbicularis muscle, tarsus, and orbital fascia, tarsal glands, and conjunctiva; the upper lid also contains the aponeurosis of the levator palpebræ, which is attached along the upper margin of the tarsal plate.

The **tarsi** are laminae of condensed connective tissue found in each lid; the superior, the larger, is half oval in shape, the lower a narrow oblong strip. In their substance are lodged the tarsal glands. Each tarsus is at its edge (except towards the palpebral fissure, where it is free) continuous with the membranous sheet known as the orbital fascia, while medially it receives the medial palpebral ligament. The superior tarsus receives above the main insertion of the levator palpebrae superioris.

The **palpebral fascia** forms an incomplete diaphragm for the anterior orifice of the orbit; peripherally it is attached to orbital margin and centrally to edge of tarsus.

The **conjunctiva** is the membrane which forms the most posterior layer of both eyelids, at the free edges of which it joins the skin. It is firmly attached to the deep surface of each tarsal plate (to prevent wrinkling), beyond this it is reflected on to the eyeball, the lines of reflection being known as the *fornices*, of which the superior is the deeper; into it some fibres of the levator palpebrae superioris are inserted. Over the eyeball, the conjunctiva is loosely connected to the sclera. The conjunctival sac has opening into it above and laterally the ducts of the lacrimal gland, and below the openings of the lacrimal canaliculi at the *puncta lacrimalia*.

The **lacrimal gland** occupies a depression in the supero-lateral angle of the orbit; the anterior margin is connected to the back part of the upper eyelid. The ducts (12 or 14) open by apertures, placed in a row, on the superior conjunctival fornix.

The **lacrimal canaliculi** commence at the *puncta lacrimalia*, which are their openings on the conjunctiva and, arching in the free edge of the lid, pass medially to open into the *lacrimal sac*.

The **lacrimal sac** is placed in a groove formed by the lacrimal bone and the frontal process of the maxilla, being behind the medial palpebral ligament, and in front of the lacrimal part of the orbicularis muscle; it is the dilated upper end of the naso-lacrimal duct.

The **naso-lacrimal duct**, formed by the lacrimal, maxilla and inferior nasal concha (bones), leads from the lacrimal sac to the inferior meatus of the nose, where it opens, the aperture being partly guarded by the lacrimal fold formed of the mucous membrane. It is about $\frac{1}{2}$ inch long, and is directed downwards, and slightly laterally and backwards.

THE EYE.

The **eyeball** is contained within the orbit; its shape is spherical, with the segment of a smaller sphere, corresponding to the cornea, superimposed anteriorly.

The eyeball consists of three coats enclosing three refractive media.

1st coat, fibrous	Sclera.
			Cornea.
			Choroid.
2nd coat, vascular, pigmented			Ciliary body.
			Iris
3rd coat, nervous	Retina.

The refractive media are—

1. Aqueous humor.
2. Vitreous body.
3. The lens

Covering the posterior $\frac{2}{3}$ of the eyeball is a layer of fascia, the *fascial sheath of eyeball* (capsule of Tenon), continuous posteriorly with the sclera at the entrance of the optic nerve, whilst anteriorly at the sclero-corneal junction it is connected with it by loose tissue only, and is pierced by the tendons of the muscles of the eyeball. It is connected with the eyeball only by delicate connective tissue, the interval forming a potential space like a bursa, to facilitate movements of the eyeball.

The **sclera** is opaque and fibrous, and occupies the posterior $\frac{2}{3}$ of the eyeball, being continuous in front with the cornea, at the sclero-corneal junction.

The *outer surface* is white and smooth, receiving the insertions of the recti and oblique muscles.

The *inner surface* is of a light-brown colour, due to a lining of pigmented connective tissue, the *lamina fusca*, which is connected by fine filaments to the choroid coat. Between the sclera and choroid is the supra-choroidal space transmitting branches of the ciliary vessels and nerves.

The optic nerve passes through the posterior part of the sclera, about $\frac{1}{8}$ inch medial to the axis of the eyeball, the point of perforation being called the *lamina cribrosa scleræ*. At its entrance, the outer sheath of

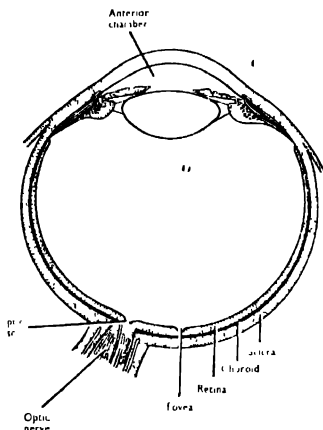


FIG. 60.—HORIZONTAL SECTION OF EYEBALL.

the nerve (dura mater) blends with the sclera. (Fig. 60).

The sclera is thickest at its posterior part, gradually thinning until about $\frac{1}{8}$ inch from the cornea, where it thickens again.

Close to the junction of the cornea with the sclera is a small circumferential canal called the *sinus venosus scleræ*.

The *bloodvessels* of the sclera are few in number, but

near its junction with the cornea there is a vascular zone derived from the anterior ciliary branches of the ophthalmic artery.

The **cornea** is the anterior transparent part of the outer coat of the eyeball, occupying about $\frac{1}{4}$ of the circumference of the globe. It projects forward beyond the curvature of the sclera, being the segment of a smaller sphere. The posterior surface is concave, and projects further backwards than the anterior convex surface, being overlapped by the edge of the sclera; this surface forms the anterior boundary of the anterior chamber of the eye, containing the aqueous humor (Figs. 60, 61).

At the circumference of the cornea some of the fibres which form its stroma are continued backwards and outwards into the sclera and iris; those going to the iris are called the *pectinate ligament of iris*; they form an annular meshwork enclosing a series of spaces (*spaces of irido-corneal angle*) which communicate with the anterior chamber.

The **choroid coat** is situated between the sclera and the retina, and is the vascular tunic of the eyeball. It is continued anteriorly into the ciliary body, forming a number of projections, folding inwards, and arranged in a circle, known as the *ciliary processes*.

The choroid coat is thickest behind, where it is pierced by the optic nerve.

Externally it is connected to the sclera by loose connective tissue (*suprachoroid lamina*) traversed by vessels and nerves as before described. Internally it is covered by the pigmented cells of the retina.

The choroid consists of bloodvessels connected together by loose connective tissue, and containing large branched and pigmented cells.

It is made up of two layers, an outer and an inner. The outer layer (*vascular lamina*) contains the larger branches of the vessels. The arteries, the short posterior ciliary, pierce the sclera close to the optic nerve, pass forwards, and bend inwards to end in the inner layer.

The veins are external to the arteries and join together into four or five principal trunks, which pierce

the sclera midway between the cornea and the optic nerve.

The inner coat (*chorio-capillary lamina*) is formed by the capillary endings of the vessels of the outer coat; they pass forwards to $\frac{1}{8}$ inch from the cornea, joining those of the ciliary processes.

The **ciliary body** consists of the ciliary processes and the ciliary muscle.

The **ciliary processes** are of the same structure as the rest of the choroid. They are about seventy in number, and are placed in corresponding depressions upon the surface of the vitreous body, and upon the ciliary zonule. The bloodvessels are derived from the anterior ciliary branches of the arteries to the recti.

The **ciliary muscle** consists of two sets of involuntary muscular fibres, meridional and circular. (Nerve supply from oculo-motor—p. 241.)

The *meridional* arise from the sclera close to the junction with the cornea, and are inserted into the choroid opposite the ciliary processes.

The *circular*: A zone of circular fibres internal to the meridional, at the base of the ciliary processes.

The **iris** is the coloured membrane suspended in the aqueous humor behind the cornea and in front of the lens. In the centre is a circular aperture, the *pupil* (Fig. 61).

It is connected at its circumference to the ciliary body, being continuous with it; and anterior to this it is attached to the cornea by the pectinate ligament of the iris.

The anterior surface is coloured and marked by wavy lines converging towards the free edge of the pupil.

The posterior surface is darkly pigmented (*uvea*) and marked with folds prolonged from the ciliary processes.

The framework of the iris is a delicate stroma of connective tissue, containing bloodvessels, nerves, pigment cells, and two groups of involuntary muscular fibres:

The *sphincter of pupil*, a narrow band of fibres placed posteriorly close to the pupil (oculo-motor).

The *dilator of pupil*, commencing at the outer margin of the iris, with the fibres converging towards the pupil (sympathetic nerve).

The *bloodvessels* of the iris consist of the two long posterior ciliary and the anterior ciliary arteries; the former pierce the sclera close to the optic nerve, and pass forwards in the space between the lamina fusca of the sclera and the suprachoroid lamina of

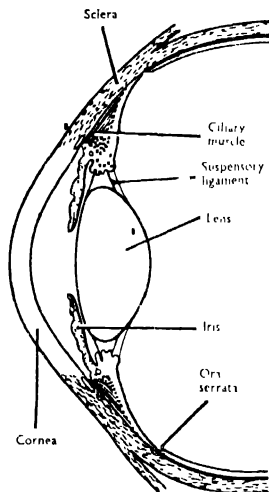


FIG. 61 -- EQUATORIAL SECTION OF ANTERIOR PART OF EYEBALL.

the choroid to enter the outer surface of the iris, having previously divided into two branches. They anastomose with the corresponding vessels of the opposite side, and with those from the vascular zone of the sclera, formed by the anterior ciliary arteries. These form the *greater arterial circle of iris*. Small branches from this circle converge towards the pupil, and freely anastomose with one another, forming the *lesser arterial circle*.

The veins follow the same arrangement as the arteries, and drain into veins of choroid coat.

The nerves of the choroid and iris are about fifteen in number, and are the *ciliary nerves*, from the ciliary ganglion and the naso-ciliary branch of the trigeminal; they follow very closely the course of the bloodvessels and, reaching the ciliary body, form a plexus, sending twigs to the ciliary muscle, iris, and cornea.

The **retina** is the expanded termination of the optic nerve, and forms the innermost tunic of the eye. It reaches forwards nearly as far as the ciliary processes, where it ends in a saw-edged border, the *ora serrata*, and from this border there is prolonged a thin layer as far as the ciliary processes, which blends with the uvea of the iris. This prolongation contains no nerve-fibres, and is called the ciliary part of retina. (Fig. 61).

The *outer* surface is covered with uveal pigment-cells (formerly described as part of the choroid).

The *inner* surface contains:

The *macula lutea*, or yellow spot, situated in the axis of the globe

The *fovea centralis*, a depression in the preceding.

The optic disc, about $\frac{1}{10}$ inch to the medial side of the yellow spot, where the optic nerve enters, and from which its fibres radiate; coursing over the optic disc may be seen the central vessels of the retina.

Blood vessels of the retina :

The central artery of the retina passes through the optic nerve, and reaches the inner surface of the retina through the disc. It here divides into two branches, a superior and inferior, and each of these, again, into a lateral or temporal division, and a medial or nasal

The lateral branches give small offsets to end in capillaries round the fovea. The rest of the branches are distributed, as capillaries, to the retina, as far as the ora serrata, but the smaller branches do not anastomose with one another or with any other vessels. The veins follow the same distribution as the arteries

The **vitreous body** is a soft gelatinous substance occupying about $\frac{2}{3}$ of the eyeball. It supports the retina behind, and is hollowed out in front for the lens.

Between the retina and the vitreous, and enclosing the latter except in front, is a thin capsule, the *hyaloid membrane*.

This membrane passes forwards in front to the anterior part of the margin of the lens. It becomes stronger in this part, and is called the *ciliary zonule* (suspensory ligament).

The zonule commences near the ciliary processes, and passes forwards to the front of the lens, and is attached in front to the lens capsule. In addition some fibres are attached to the extreme edge of the lens, and others become continuous with the posterior part of the capsule.

The interstices between these fibres are occupied by fluid, but after death they may be distended with air, and an appearance of a canal (*zonular spaces*) encircling the lens is produced.

Extending forwards from the optic disc through the vitreous, as far as the capsule of the lens, is the *hyaloid canal*, which is the remains of a passage for a branch from the central artery of the retina in the foetus.

The **lens** is a transparent biconvex body enclosed in a transparent membrane, the lens capsule. It is in contact anteriorly with the iris; posteriorly it rests in a depression in the vitreous body, and it is surrounded by the *suspensory ligament*, connecting it to the ciliary processes. It is about $\frac{1}{2}$ inch in diameter, and about $\frac{1}{8}$ inch thick.

The **capsule of lens** is the structureless membrane enclosing the lens, thick in front near its circumference, where it is strengthened by the fibres of the zonule, but very thin posteriorly.

The **aqueous humour** and the **aqueous chambers**: The aqueous humour occupies the space between the anterior surface of the lens capsule and the posterior surface of the cornea.

The iris divides the chamber into two parts, known as the anterior and posterior chambers.

The *anterior chamber* is bounded in front by the cornea, behind by the iris, and opposite the pupil by the anterior part of the lens. (Fig. 60).

The *posterior chamber* is the triangular interval at the circumference of the lens between the ciliary processes, the iris, and the ciliary zonule

THE EXTRINSIC MUSCLES OF THE EYE

These are the four *recti* and two *obliqui*. With the exception of the inferior oblique they all arise from a circumscribed area at the back of the orbit, and diverge forwards to surround the eyeball—forming the “cone of muscles.” The **four recti** arise from a fibrous band surrounding the optic foramen and crossing the medial part of the superior orbital fissure—the *common tendinous ring*. Each passes forwards and is *inserted* into the eyeball just behind the corneo-scleral junction (p. 313). The recti are *superior* and *inferior* (elevating and depressing the front of the eyeball), and *lateral* and *medial* (causing the eye to look laterally and medially). The **superior oblique** arises from the upper and medial part of the common tendinous ring, passes forwards along the junction of roof and medial wall of orbit, and then through the “pulley” which deflects its tendon in a “hairpin” bend backwards and laterally. It is inserted into the upper and lateral aspect of the globe behind its equator. The **inferior oblique** arises from the medial part of the front of the floor of the orbit, passes laterally *under the inferior rectus*, but *between the lateral rectus and the eyeball*, to be *inserted* into the upper and lateral quadrant of the globe behind its equator.

Nerve supplies: Oculo-motor (3) to all except lateral rectus (6) and superior oblique (4).

Actions: The lateral and medial recti act in a horizontal plane, but the superior and inferior pull the front of the eyeball medially as well as up or down.

This is corrected thus:

Rectus superior: up and in	..	} Result: vertically up.
Obliquus inferior: up and out	..	
Rectus inferior: down and in	..	} Result: vertically down
Obliquus superior: down and out		

The Organs of Digestion

THE TEETH

Temporary teeth : The following is the dental formula for the temporary teeth, with the dates in months of their eruption:—

	Mo.	Mo.	Ca.	In.	In.	In.	In.	Ca.	Mo.	Mo.	
Upper	2	1	1	2	1	1	2	1	1	2=10	} - 20
Lower	2	1	1	2	1	1	2	1	1	2=10	
	24	12	18	9	7	7	9	18	12	24 months	

Permanent teeth : Subjoined is the dental formula for the permanent teeth, with the date in years of their eruption:

	Mo		Pre.		Mo	Ca	In.	In.	In.	In.	Ca.	Pre.	Mo.	Mo			
Upper	3	2	1	2	1	1	2	1	1	2	1	1	2	1	2	3=16	} -32
Lower	3	2	1	2	1	1	2	1	1	2	1	1	2	1	2	3=16	
	18	12	6	10	9	11	8	7	7	8	11	9	10	6	12	18 years	

Dental anatomy : Pulp cavity of tooth surrounded by dentine, foramen in tip of root (*apical foramen*) transmits vessels, lymphatics and nerve filaments of pulp. Dentine capped with enamel on visible part of tooth (*Crown*), covered with cementum on root. Teeth held in sockets by *periodontal membrane*, which is vascular periosteum uniting bone of socket to cementum on root.

Number of roots : Incisors, canines and premolars one each, upper molars three roots (two buccal, one palatal), lower molars two roots (one anterior, one posterior).

THE MOUTH.

The *vestibule* lies external to teeth and gums, bounded by lips and cheeks. Mid-line mucosal fold forms frenulum of each lip. Parotid duct opens into vestibule on a papilla opposite 2nd upper molar. Many mucous glands in mucous membrane.

Floor of mouth has *sublingual papilla* on each side of frenulum linguae; submandibular duct opens on it. Behind papilla is *sublingual fold* overlying sublingual salivary gland, ducts of which open on the fold.

THE TONGUE

The **tongue** occupies the floor of the mouth; its base is connected with the hyoid bone, the epiglottis, the palato-glossal arches, and with the pharynx; along its inferior surface the genio-glossus runs from base to tip, connecting it to the mandible and hyoid bone.

The **mucous membrane** on the under surface is smooth, forming in front a median fold, the *frenulum linguae*; on the sides it is continuous with the mucous membrane of the mouth. Dorsum of tongue lies part in mouth (anterior two-thirds) and part in oropharynx (posterior one-third). Vallate papillae mark the junction. Anterior two-thirds of dorsum covered with papillae ("fur" of tongue.) Here a shallow sulcus leads back in midline to *foramen caecum*. Posteriorly the epiglottis is connected to the tongue by three glosso-epiglottic folds, a median and two lateral, enclosing the *valleculae*. The anterior two-thirds of the dorsum of the tongue is covered with papillae. The *filiform papillae* are numerous, and are arranged in rows parallel to the vallate, but towards the tip of the tongue their direction becomes more transverse. They are keratinized.

The *fungiform papillae*: Found principally at the apex and on the sides. Not keratinized.

The *vallate papillae* (seven to ten) form a row on each side at the back of the tongue, meeting in the middle line thus, **Λ**, in front of the foramen caecum. They belong to the posterior third.

Glands: A mucous gland in each half of anterior two-thirds (*anterior lingual gland*) opens by 12-16 ducts on smooth undersurface alongside frenulum.

Posterior third of tongue is nodular from underlying lymphoid tissue (*lingual tonsil*) and mucous glands.

THE MUSCLES OF THE TONGUE: The *extrinsic* muscles of the tongue are attached to bone—they alter *position* and shape of tongue. *Intrinsic* muscles lie wholly in tongue and can alter *shape* only.

Genio-glossus—*Origin:* Superior genial tubercle on inner surface of mandible near symphysis.

Insertion: Body of hyoid bone (posterior fibres); dorsal surface of tongue from root to tip (anterior fibres). Forms main bulk of the tongue. Separated by midline fibrous septum.

Nerve supply: Hypoglossal.

Action: Inferior fibres raise tongue and hyoid bone, draw tongue forwards and protrude it to opposite side. Anterior fibres withdraw tip of protruded tongue.

Hyo-glossus: *Origin:* From side of body, all greater horn of hyoid and from lesser horn.

Insertion: Back and side of tongue, interdigitating with stylo-glossus.

Nerve supply: Hypoglossal.

Action: Depresses sides of tongue, making surface convex transversely.

Parts beneath hyo-glossus: Inferior longitudinal muscle of tongue, genio-glossus and middle constrictor muscles, lingual vessels, stylo-hyoid ligament below, glosso-pharyngeal nerve above. Relationships of hyo-glossus include all floor structures of mouth (Fig. 62).

Stylo-glossus—*Origin:* Lateral surface of apex of styloid process and stylo-hyoid ligament.

Insertion: Side of dorsum of tongue, interdigitating with hyo-glossus.

Nerve supply: Hypoglossal.

Action: Draws tongue upwards and backwards; makes superior surface concave transversely.

Palato-glossus (*palato-glossal arch*)—*Origin:* Inferior and lateral surface of soft palate.

Insertion : Side and dorsum of tongue.

Nerve supply : Pharyngeal plexus.

Action : Approximates back of tongue and soft palate. The two constitute oro-pharyngeal isthmus.

The *intrinsic* muscles are entirely contained within the substance of the tongue, and are all supplied by hypoglossal nerve. They are as follows:—

Superior longitudinal muscle : One on each side.

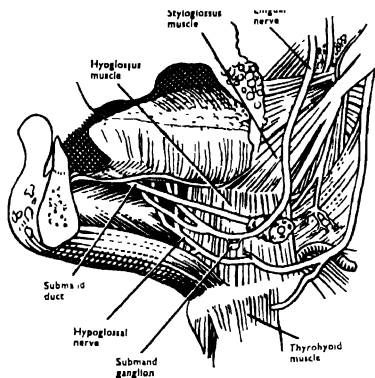


FIG. 62.—THE FLOOR OF THE MOUTH EXPOSED BY REMOVAL OF THE LEFT HALF OF THE MANDIBLE, AND MYLO-HYOID MUSCLE.

Longitudinal fibres lying under the mucous membrane. It arises from the median glosso-epiglottic fold, and from the septum along the middle line; the fibres pass obliquely outwards, the anterior fibres being longitudinal, to the side of the tongue.

Inferior longitudinal muscle is a bundle of muscular fibres running along the under surface of the tongue from base to tip on each side. It lies between the genio-glossus and hyo-glossus muscles. It arises from the septum at the base of the tongue, is joined anteriorly with some fibres of the stylo-glossus, and passes to the tip.

Transverse muscle forms a horizontal layer of muscular fibres between the superior and inferior longitudinal muscles. The fibres spring from the septum and pass laterally to the sides of the tongue.

Vertical muscle of tongue arises from dorsum, and mingles with transverse fibres.

The **septum** of the tongue is a vertical fibrous partition extending, in the muscular portion, from the hyoid bone to the tip.

Arteries : Lingual, tonsillar of facial.

Nerves : Lingual of mandibular (inc. chorda tympani) to anterior two-thirds; glosso-pharyngeal to posterior third; hypoglossal to muscles.

THE PALATE

The **palate** forms the roof of the mouth, and consists of two parts—the front being the hard palate and the back the soft palate.

The **hard palate** consists of the palatine processes of the maxillæ and horizontal plates of the palatine bones, together with the mucous membrane and the periosteum adherent to them (muco-periosteum). The greater palatine artery and nerve run forwards (artery lateral to nerve) near the alveolus. There are many small mucous glands.

The **soft palate**, consisting of muscles, aponeurosis, vessels, nerves, etc., enclosed between two layers of mucous membrane, is attached in front to the posterior margin of the bony palate, the sides blending with the pharynx; from the middle of the posterior edge the *uvula* projects, and from the bases of this arch, on each side, there are two folds of mucous membrane enclosing muscular fibres—the palato-glossal and palato-pharyngeal arches, between which the tonsil lies. The narrowed passage between the anterior arches, leading from the mouth to the pharynx, is called the *oro-pharyngeal isthmus*.

The **aponeurosis** of the soft palate, attached to the crest of the palatine bone and the posterior edge of the bony palate, is formed by the tendon of the tensor palati after it hooks around the hamulus. Oral

surface covered by thick mucous glands that extend back into uvula.

MUSCLES OF THE SOFT PALATE

Tensor palati—*Origin*: Scaphoid fossa at base of medial pterygoid plate, cartilaginous part of pharyngo-tympanic tube and spine of sphenoid.

Insertion: Tendon winds round hamulus and passes above buccinator to form broad *palatine aponeurosis* attached to crest of palatine bone and posterior border of hard palate.

Nerve supply: Mandibular nerve by twig passing through otic ganglion.

Levator palati—*Origin*: Lower surface of apex of petrous bone, and medial surface of cartilaginous part of pharyngo-tympanic tube.

Insertion: Upper surface of palatine aponeurosis.

Nerve supply: Accessory through pharyngeal branch of vagus to pharyngeal plexus.

Azygos uvulae: Two small slips lying on either side of mid-line in substance of uvula

The *palato-glossus* and *palato-pharyngeus* forming the faucial pillars (arches of oro-pharyngeal isthmus) belong respectively to the tongue (p. 321) and pharynx (p. 329).

Movements of Soft Palate: Tensor palati renders the aponeurosis more tense, and thereby flattens and slightly depresses it. Levator palati raises the tensed palate to shut off the naso-pharyngeal isthmus in swallowing. Lower head of palato-pharyngeus (p. 329) depresses soft palate to close oro-pharyngeal isthmus. Palato-glossus raises tongue, but its upper attachment is too far forward to have much effect on soft palate itself.

The **tonsils** occupy the recesses between the arches of the oro-pharyngeal isthmus, the anterior arch being formed by the palato-glossus and the posterior by the palato-pharyngeus. Lateral to each is the superior constrictor, and medially the pharyngeal mucous membrane. Their arterial supply is large, from the ascending pharyngeal, ascending and greater palatine, tonsillar, and dorsalis linguæ arteries.

THE SALIVARY GLANDS

The **PAROTID GLAND** is the largest, and lies between the external auditory meatus and mastoid process behind, and the ramus of the mandible in front. Anteriorly, it overlaps the hinder part of the masseter. It is enclosed between two layers of cervical fascia (parotid fascia).

The deep surface is irregular, and is grooved obliquely by the styloid process and its attached muscles; behind this process a lobe passes medially lying on the internal jugular vein, and glosso-pharyngeal, vagus, and accessory nerves. In front of the styloid process a large lobe (carotid) overlies the internal carotid artery, and lies medial to the ramus and medial pterygoid.

The *accessory parotid gland* is a separate lobe projecting from the anterior border, and lies on the masseter.

The **parotid duct** is 2 inches long; comes off from the anterior border and crosses the masseter to pierce the buccinator and buccal mucous membrane. Its opening in the mouth is on a papilla opposite the 2nd upper molar tooth.

Course of the duct: Middle third of a line from inter-tragic notch to middle of upper lip. *The duct is palpable.* The transverse facial artery lies above the duct, and the buccal branch of the facial nerve below.

The parotid gland is traversed by the external carotid artery, retromandibular (posterior facial) vein and, near the surface, by the branches of the facial nerve.

Embedded in it superficially are several pre-auricular lymph glands.

Nerve supply of gland: Sympathetic, and parasympathetic in the glosso-pharyngeal. The latter branch may be traced as follows: the tympanic branch gives off lesser (superficial) petrosal, which relays in otic ganglion and joins the auriculo-temporal trunk, thus supplying the gland. Sympathetic from plexus

around middle meningeal artery (cell bodies in superior cervical ganglion).

The **SUBMANDIBULAR GLAND** lies under cover of the body of the mandible.

Superficial lobe : Separated by stylo-mandibular ligament from parotid, grooved above and behind by facial artery.

<i>Lies upon</i>	<i>Superficial Coverings</i>	<i>Below.</i>
Mylo-hyoid.	Platysma.	Tendon of
Stylo-hyoid.	Cervical fascia.	digastric.
Hyo-glossus	Common facial vein	
Digastric	Body of mandible.	
(anterior belly).	Submandibular lymphatic nodes.	

Deep lobe : Passes with duct between mylo-hyoid and hyo-glossus around posterior free border of mylo-hyoid.

The **submandibular duct**, passes with deep lobe of gland beneath mylo-hyoid, resting on the hyo-glossus. At first the lingual nerve lies above the duct and the hypoglossal nerve below, but the duct, crossing above the lingual nerve, passes upwards and forwards on genio-glossus to open on the papilla by the side of the frenulum linguæ.

Nerves : Sympathetic on facial artery and parasympathetic in chorda tympani through submandibular ganglion.

The **SUBLINGUAL GLAND** occupies the sublingual fossa of mandible, lying under mucous membrane of floor of mouth, and having its anterior extremity close to the frenulum. Below is the mylo-hyoid, and medially is the genio-glossus.

Sublingual ducts (18 to 20) : Open separately in the floor of the mouth. One from the posterior part, the larger sublingual duct, opens into or by the side of the submandibular duct.

Nerves : Sympathetic, and from parasympathetic (chorda tympani) through submandibular ganglion.

Labial and molar glands : Lie in mucous membrane of lips and cheek.

THE PHARYNX

The **pharynx** is an oval musculo-membranous bag ~~dependent from base of skull~~ and attached behind the nose, mouth, and larynx. Above, where it is a part of both respiratory and alimentary tract, its walls are rigid and it is always patent; below the level of laryngeal aperture it is normally merely a transverse slit (hypopharynx), which opens upon deglutition. The part above soft palate is the *naso-pharynx*; that behind the mouth, the *oral pharynx*, below which is the *laryngeal pharynx*. It is $4\frac{1}{2}$ to 5 inches long, and extends from the base of the skull to the lower border of the cricoid cartilage in front, and to the lower border of 6th cervical vertebra behind. It is widest opposite the hyoid bone. Behind, it is separated by the prevertebral fascia from the longus cervicis and capitis muscles of each side. Below, it is continuous with the œsophagus.

Attachments

Superior: Pharyngeal tubercle of occiput, under surface of petrous of temporal, cartilaginous part of tube—this is the pharyngo-basilar fascia, the wall of the naso-pharynx.

Anterior: Medial pterygoid plate, pterygo-mandibular raphé, mandible, base of tongue, horns of hyoid bone, and stylo-hyoid ligament; thyroid and cricoid cartilages, corresponding to attachments of constrictor muscles.

Arteries: Ascending pharyngeal; pterygo-palatine; ascending and descending palatine; dorsalis linguæ; tonsillar.

Openings: The *posterior apertures of nose* (2), placed in the upper part of the anterior wall; *pharyngo-tympanic tubes* (2), open one on each side at the upper part; the *mouth*, situated just below the posterior apertures of nose; the *laryngeal* and *œsophageal* openings.

The **pharyngo-basilar fascia** forms the basis of the walls of the nasal pharynx. It is thin below, but strong above, where it fills in the space above the upper crescentic margin of the superior constrictor,

over which the pharyngo-tympanic tube passes. It is attached above to the body of the occiput and petrous portion of the temporal; being strengthened in the middle line by a process of fascia attached to the pharyngeal tubercle on the basilar part of the occipital bone (the pharyngeal ligament). Inferiorly it becomes lost between the muscular and mucous strata.

Recesses of pharynx: In nasal part is a narrow slit between tube and prevertebral muscles, the *pharyngeal recess*. In oral part, between base of tongue and epiglottis, are *vallecule*, separated by the median glosso-epiglottic fold. Each vallecule limited behind by lateral glosso-epiglottic (pharyngo-epiglottic) fold. Below latter, in laryngeal part of pharynx between laryngeal aperture and side wall of pharynx, is the *piriform fossa*.

THE MUSCLES OF THE PHARYNX

Superior constrictor—*Origin*: (1) Posterior border of medial pterygoid lamina; (2) pterygo-mandibular raphe, (3) mylo-hyoid ridge of mandible; (4) side of tongue.

Insertion: (1) Pharyngeal tubercle at base of skull; (2) median raphe extending down in mid-line from pharyngeal tubercle, blending with fellow of opposite side down to level of vocal folds. The muscle embraces lower part of pharyngo-basilar fascia.

Middle constrictor—*Origin*: (1) Upper border of great cornu of hyoid bone; (2) lesser cornu and lower part of stylo-hyoid ligament.

Insertion: Median raphe, overlapping superior constrictor down to level of vocal folds (Fig. 63).

Inferior constrictor—*Origin*: (1) Outer surface of thyroid cartilage behind oblique line; (2) cricoid cartilage.

Insertion: Thyroid part into median raphe, below level of vocal folds (muscle wall thin here, called dehiscence, site of diverticulum). Cricoid fibres are sphincteric (no raphe) and named crico-pharyngeus muscle.

Nerve supply: The constrictors are supplied by the

accessory nerve (nucleus ambiguus) through the pharyngeal plexus. Crico-pharyngeus by recurrent and external laryngeal nerves.

Stylo-pharyngeus—*Origin* : Root of styloid process.

Insertion . (1) Posterior border of thyroid cartilage; (2) wall of pharynx. (Fig. 63).

Nerve supply : Glossopharyngeal (nucleus ambiguus).

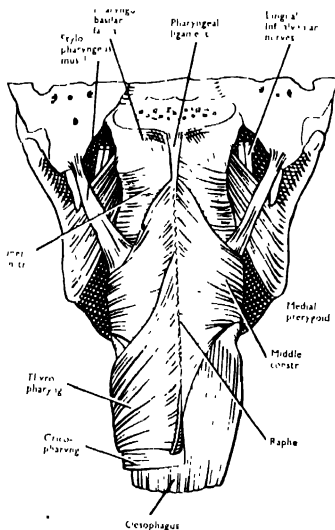


FIG. 63.—THE PHARYNX FROM BEHIND.

The inferior constrictor is removed from the right side.*

Action : Pulls larynx and pharynx up in swallowing.

Palato-pharyngeus—*Origin* : Upper surface of palatine aponeurosis, two heads embracing levator palati insertion. Upper head from hard palate behind crest, lower head from aponeurosis only.

Insertion : Side of pharynx, blending with superior constrictor. Posterior border of thyroid cartilage.

Nerve supply: Accessory (nucleus ambiguus), through pharyngeal plexus.

Action: Pulls larynx and pharynx up and closes fauces in swallowing.

Palato-pharyngeal sphincter: Lies horizontal, a U-shaped sling within the superior constrictor, limbs attached on posterior margin of hard palate lateral to upper head of palato-pharyngeus. Its contraction raises a ridge (Passavant's ridge) against which soft palate is elevated in swallowing. Muscle is greatly hypertrophied in cleft palate.

Salpingo-pharyngeus—Origin: Medial end of cartilaginous tube.

Insertion: Thyroid lamina and side wall of pharynx. Makes a ridge (salpingo-pharyngeal fold) in mucosa below tubal elevation.

Action: Pulls larynx and pharynx up in swallowing, at same time opening cartilaginous part of pharyngo-tympanic tube (latter done also by tensor and levator palati).

THE ŒSOPHAGUS

The Œsophagus extends from pharynx to stomach, and is 10 inches long. It begins at the lower border of cricoid cartilage opposite the 6th cervical, and ends opposite the 11th thoracic vertebra.

The distance from the front teeth to the junction of Œsophagus and stomach is 16 inches.

Course and relations.

In the neck: Passes downwards and slightly to the left.

<i>Anterior.</i>	<i>Posterior.</i>	<i>Left Side.</i>		<i>Right Side.</i>
Trachea.	Vertebrae.	Left inferior thyroid	} <i>Arteries.</i>	Right carotid artery.
Thyroid gland.	Left longus cervicis muscle.	Left carotid		Right recurrent laryngeal nerve.
Left recurrent laryngeal nerve.	Prevertebral fascia.	Left subclavian		
		Thoracic duct.		

In the chest: *In the superior mediastinum:* Passes downwards to the right to reach middle line opposite 5th thoracic vertebra.

In the posterior mediastinum : Passes forwards, downwards and to the left, with the two vagi, which form a plexus on its surface; the left nerve is anterior, and the right is posterior.

<i>Anterior.</i>	<i>Posterior.</i>	<i>Left Side.</i>	<i>Right Side.</i>
Left carotid artery.	Longus cervicis.	Left subclavian artery.	Right pleura.
Bifurcation of trachea.	Vertebræ.	Left vagus nerve.	Vena azygos.
Right pulmonary artery.	Thoracic duct.	Arch of aorta.	
Left bronchus.	Venæ hæmazygos.	Thoracic aorta.	
Left recurrent laryngeal nerve.	Right intercostal arteries.	Left pleura.	
Pericardium and left atrium.	Aorta (below).		
Diaphragm.			

In the abdomen : Passes through œsophageal opening in diaphragm opposite the left 6th costal cartilage and 10th thoracic vertebra, to end immediately at the cardiac opening of the stomach.

STRUCTURE OF THE ŒSOPHAGUS: Three coats: (1) Mucous membrane lined by stratified squamous epithelium. (2) Submucous, areolar tissue with many mucous glands. (3) Muscular, two layers; inner circular, outer longitudinal; both layers consist of striated muscle above, but soon contain only smooth muscle.

NERVES: Upper third, vagi via recurrent laryngeal nerves, sympathetic from middle cervical ganglion via inferior thyroid artery. Below lung roots, vagi and sympathetic in œsophageal plexus.

ARTERIES: Œsophageal from inferior thyroid, thoracic aorta and right intercostals, and at lower end left gastric.

Note that left gastric (portal) vein anastomoses in lower œsophagus with systemic veins.

THE STOMACH

The *form and position* of the stomach in the living subject is unlike the flaccid bag seen in the cadaver. In the living, when not distended, the stomach is contracted, and its position varies in the erect or prone posture, and with the relative distension of the intestines. In the erect posture, when containing a small

amount of fluid, its form is J-shaped; the vertical stalk of the J represents the upper $\frac{3}{4}$ of the stomach (*cardiac part*) which is surmounted by a convex cap (*the fundus*); on the right, below the fundus, the cardiac orifice leads from the œsophagus; the right margin (*lesser curvature*), which is vertical in its upper $\frac{3}{4}$, turns upwards and to the right below, where it limits the *pyloric part*; the curve between the two parts is known as the *angular notch*. The left margin of the cardiac portion is variably convex (*greater curvature*), and below may reach or lie below the umbilicus; it then passes upwards and to the right as the lower margin of the pyloric portion. To the lesser curvature is attached the lesser omentum, and to the greater curvature the greater omentum, which to the left is continuous with the gastro-splenic ligament. The cardiac orifice is fixed by the passage of the œsophagus through the diaphragm, and lies opposite the 10th thoracic vertebra, and behind a point on the 7th left costal cartilage 1 inch from the sternum. The pylorus is palpable as a thickening of the circular muscular coat (*pyloric sphincter*), and is also marked by a pyloric vein; it is movable to the right as the stomach distends, but usually lies within 1 inch, and to the right, of the mid-line opposite the body of the first lumbar vertebra; this, the transpyloric plane, is the mid-point of a line joining the suprasternal notch with the upper border of the pubis. The pylorus lies in contact with the under surface of the quadrate lobe or of the neck of the gall-bladder.

The anterior surface is covered by peritoneum (*greater sac*) and the posterior surface by the lesser sac, except near the cardiac orifice.

Relations :

Anterior surface, which also looks upwards, is in contact with, from left to right, diaphragm, abdominal parietes (epigastric region), under surface of liver.

Posterior surface is separated from diaphragm, aorta, pancreas, spleen, left kidney and suprarenal, transverse mesocolon and colon, by lesser sac of peritoneum.

The stomach lies in the epigastric and umbilical

regions of the abdomen; when distended it may encroach upon the left hypochondriac region.

ARTERIES.—*Right* and *left gastric* run along lesser curvature; *right* and *left gastro-epiploic*, along greater curvature; *short gastric branches*, from the splenic to fundus.

NERVES.—*Right vagus*, to posterior surface; *left vagus*, to anterior surface; *sympathetic*, from the coeliac plexus to both surfaces

STRUCTURE OF THE STOMACH: Four layers: (1) Mucous membrane, very rugose. (2) Abundant submucous layer. (3) Muscular coat, oblique, circular, and longitudinal from within outwards. (4) Serous from peritoneum.

THE SMALL INTESTINE

THE DUODENUM

Length : 10 inches.

Shape : Horse-shoe, with the convexity to the right side, the concavity enclosing the head of the pancreas.

Position : Lies in epigastric and umbilical regions

Has no mesentery, and is only partially invested by peritoneum.

Divided into four parts.

Relations :

1st part : 2 inches long; directed from pylorus upwards, backwards, and to the right, reaching the neck of the gall-bladder. The 1st inch is invested with peritoneum, but the 2nd inch is covered in front only.

Anterior and superior : Liver, gall-bladder.

Posterior : Common bile-duct, portal vein, hepatic artery, gastro-duodenal artery.

Superior : Opening of lesser sac, and lesser omentum.

Inferior : Head of pancreas.

2nd part : 3 inches long; is vertical; passes from opposite neck of gall-bladder down to 3rd lumbar vertebra. Bile and pancreatic ducts enter at *duodenal papilla*. Covered in front by peritoneum, except where crossed by transverse colon.

Anterior : Transverse colon, liver and gall-bladder, small intestines.

Posterior : Right kidney, suprarenal gland, renal vessels, and inferior vena cava.

Left side : Head of pancreas, bile-duct, and pancreatic duct.

Right side : Right flexure of colon.

On the inner aspect, $3\frac{1}{2}$ or 4 inches from the pylorus, is the *duodenal papilla*, on which is the orifice for both the bile and pancreatic ducts. *Horizontal part*

3rd part : About 4 inches long; passes from right to left ~~across spine~~, ascending from 3rd to 2nd lumbar vertebra, ends on left side of spinal column; lies below transverse mesocolon, and is covered in front by peritoneum, except where foot of mesentery crosses it.

Relations.
Anterior : Superior mesenteric vessels and plexus.

Posterior : Aorta, inferior vena cava, crura of diaphragm, left psoas, and left renal vessels.

Superior : Pancreas.

4th part : About 1 inch long. Ascends vertically on left psoas to side of 2nd lumbar vertebra, turns forward to join jejunum.

Anterior : Peritoneum, jejunum and transverse colon.

Posterior : Left testicular artery, sympathetic trunk and psoas.

Medial : Pancreas.

DUODENO-JEJUNAL FLEXURE: On the left of the 2nd lumbar vertebra the small intestine forms an acute bend forwards, downwards, and to the left, the duodeno-jejunal flexure; this is supported to the right crus of the diaphragm by a band of unstriated muscle, known as the *suspensory muscle of duodenum* (Treitz). To the left of the flexure is seen the para-duodenal fossa with the inferior mesenteric vein forming its prominent left margin.

ARTERIES: Right gastric, and superior pancreatico-duodenal of hepatic, inferior pancreatico-duodenal of superior mesenteric.

NERVES: From coeliac plexus (vagal and sympathetic).

THE JEJUNUM AND ILEUM

The jejunum forms $\frac{2}{3}$ of the rest of the small intestine, which is up to 23 feet long; commencing on the left side of the 2nd lumbar vertebra, it terminates in the ileum; it is wider, and its coats are thicker, more vascular, and of a deeper colour than the ileum.

The ileum consists of the remaining $\frac{1}{3}$ of the small intestine, and terminates in the right iliac fossa by opening into the cæcum; some coils about 2 feet in length and distant 1 foot from ileo-cæcal valve lie in pelvis.

The ileum with the jejunum is suspended from the posterior abdominal wall by the mesentery (see p. 348). The vessels are derived from the superior mesenteric artery, and the veins drain into the vein of the same name.

STRUCTURE OF SMALL INTESTINE: (1) Mucous membrane, lined by columnar epithelium and raised, especially in duodenum, in plicæ circulares; a prominent plica surmounts the duodenal papilla, and from its lower margin a vertical plica runs down a short distance. Villi and intestinal glands throughout. Aggregated lymphatic follicles (Peyer's patches), of oblong shape, with long axis along that of bowel, are found on antimesenteric aspect, chiefly in lower ileum. (2) Submucous. (3) Muscular, circular, and longitudinal. (4) Serous, incomplete over duodenum, elsewhere complete except at mesenteric border.

The following characteristics will serve to distinguish the three parts of the small intestine:

Duodenum.	Jejunum.	Ileum.
The largest part.	More vascular than	Thin-walled
Thickest coats.	ileum and larger	Plicæ circulares not
Special glands of	and thicker-walled.	present or only
Brunner in sub-	Plicæ circulares well	slightly.
mucous coat.	marked.	Aggregated lymphatic follicles
No mesentery.		
Plicæ circulares well		
marked, but absent		
in 1st part.		

THE LARGE INTESTINE

Extent : From the ileum to the anus. *Length* : 5 or 6 feet.

Characteristics of cæcum and colon : Larger size, more fixed than the small intestine; have appendices epiploicæ. The longitudinal muscular fibres are arranged in three bands (*tæniæ*), which, being shorter than the other coats, cause sacculation.

The CÆCUM is a dilated pouch in which the large intestine commences, situated in the right iliac fossa, and completely covered by peritoneum. At the lower, medial, and back part, and attached by a short triangular mesentery to the mesentery of the terminal ileum, is the *vermiform appendix*, a blind tubular projection, about 3 inches long, and about the size of a large quill.

The *ileo-colic valve* lies on the left side of the junction of the cæcum with the colon; is formed by the circular muscle of the ileum passing through the wall of the cæcum. The opening is slit-like with prominent upper and lower lips; the lips fuse at either side to form the *frænulum*.

The COLON is divided into ascending, transverse, descending, and pelvic

The **ascending colon** extends from the ileo-colic orifice to the under surface of the liver to the right of the gall bladder, where it turns to the left, forming the *right flexure (hepatic flexure)*. The peritoneum covers the anterior and lateral surfaces; the *tæniæ* are anterior, medial, and postero-lateral.

It lies posteriorly on the iliacus, quadratus lumborum, lateral part of right kidney.

The **transverse colon** passes in the umbilical region from right to left, from the gall-bladder to the spleen. It forms an arch, convex anteriorly and below. It is attached by the transverse mesocolon to the pancreas.

Relations—Superior : Liver, gall-bladder, greater curvature of stomach, inferior surface of spleen.

Inferior : Small intestines.

Anterior : Anterior layers of greater omentum, anterior abdominal wall.

Posterior : Right kidney, 2nd part of duodenum, pancreas, small intestines and left kidney.

The **descending colon** passes from the end of the

transverse colon by an acute bend, *the left flexure (splenic flexure)*; the calibre of the bowel here is very small. Between the left flexure and the diaphragm, opposite the 10th left rib, is a fold of the peritoneum, the *phrenico-colic ligament*. The gut then passes downwards to the pelvic brim, ending in the pelvic colon. The peritoneum invests its anterior and lateral surfaces; *tæniæ* as in ascending colon.

Relations—Posterior : Left kidney, quadratus lumborum, and iliacus.

Anterior : Small intestine

Medial : Lateral border of left kidney.

The **pelvic colon** extends from the medial border of the psoas to the level of the 3rd sacral vertebra. It has an extensive mesentery and forms a loop hanging into the pelvis. As its lower end is reached the longitudinal muscular coat becomes uniformly spread out over its circumference.

Relations : Passing over left brim of pelvis, it crosses left external iliac vessels and left ureter, and passes towards right margin of pelvis, resting on bladder in male and uterus in female; above he coils of small intestine. It then turns back to mid-line on posterior wall of pelvis, and, forming a second bend, ends as the rectum.

THE RECTUM:

Commences at 3rd sacral vertebra as continuation of pelvic colon; passes downwards in concavity of sacrum; at coccyx it turns forwards as dilated *ampulla* ; about 1 inch in front of the coccyx it bends sharply backwards to become the *anal canal*.

Relations : It has peritoneum on the upper $\frac{1}{2}$ of anterior and lateral surfaces only, and no mesentery.

Anterior—In the male : Recto-vesical pouch; triangular area at base of bladder, seminal vesicles, vasa deferentia, posterior surface of prostate. *In the female* : Posterior wall of vagina and recto-uterine pouch.

Posterior : Sacrum, piriformes, sacral plexuses, coccyx, levatores ani.

Lateral : Pararectal fossa, below coccygeus.

Externally the rectum shows three lateral inflections.

The highest and the lowest are concave to the left; they are produced by the relative shortness of longitudinal muscular coat, which is here spread over whole circumference of bowel. Internally they cause horizontal shelves of mucosa (*horizontal folds of rectum, valves of Houston*). In its lowest part the rectal cavity is dilated as the rectal ampulla.

STRUCTURE OF LARGE INTESTINE: (1) Mucous membrane smooth, with columnar epithelium and mucous crypts. (2) Submucosa. (3) Muscular, internal circular, outer longitudinal, latter arranged in three bands along colon, but uniform over rectum. (4) Serous, variable over colon (see pp. 336 and 337), disappears on rectum. For individual peculiarities see different parts.

THE ANAL CANAL:

Extent : From pelvic floor to anus (1 to 1½ inches long).

Direction : Downwards and backwards.

Relations — Anterior : Membranous part of the urethra, bulb of corpus spongiosum (male), posterior wall of vagina, the perineum intervening (female)

Lateral and posterior : Levatores ani, which, uniting, support it as in a sling. Internal and external sphincters. Ischio-rectal fossa.

Upper half or more of anal canal is true gut, lined by columnar epithelium. It shows *rectal columns* (*Morgagni*) produced by bloodvessels. Lower half or less of canal is ectodermal in origin and lined by skin. At junction of two regions are *anal valves* connecting lower ends of columns, and *white line* representing junction of skin with mucous membrane.

THE LIVER

Situation : Right and left hypochondriac and epigastric regions.

Average weight : 50 ounces.

Superior surface : Convex, covered by peritoneum; above is the diaphragm. It is divided descriptively into two unequal lobes (right and left) by a fold of peritoneum, called the *falciform ligament*.

Inferior surface : Concave, and is in contact with the stomach, pylorus, duodenum, right flexure of colon, right kidney, and right suprarenal gland; is covered with peritoneum, except where gall bladder is attached, and at the porta hepatis and the fissure for ligamentum venosum, which give attachment to the lesser omentum.

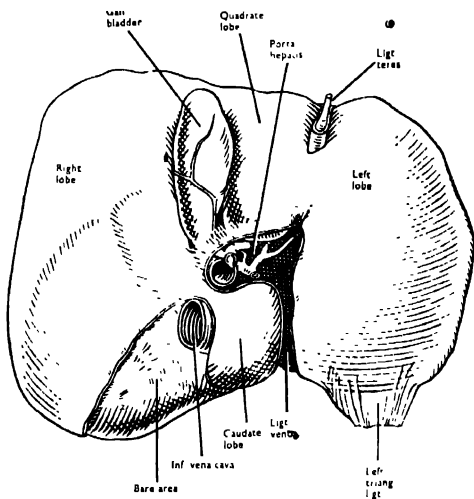


FIG. 64.—THE INFERIOR SURFACE OF THE LIVER.

Posterior surface : Is broad and round; connected to diaphragm over right lobe by the coronary ligament, between the two layers of which its surface is non-peritoneal. To left of bare area, opposite the 10th and 11th thoracic vertebræ, is the caudate lobe, which bounds the lesser sac in front. Right suprarenal, inferior vena cava, aorta, œsophagus, and lesser peritoneal sac lie behind.

Anterior surface : Triangular, and marked by a notch opposite the attachment of the falciform liga-

ment. In contact with diaphragm and anterior abdominal wall.

Right surface: Convex and, in contact with diaphragm.

The **LIGAMENTS** are five in number; four are composed of peritoneum.

The **falciform ligament**, sickle-shaped, with the base forward. It is attached to the diaphragm, and to the parietes, as far as the umbilicus, and behind to the anterior surface of the liver. The inferior edge encloses the round ligament.

The **triangular ligaments**, right and left, extend from the sides of the diaphragm to the posterior border of the liver.

The **coronary ligament** is continuous with the triangular ligaments, and attaches the posterior surface of right lobe of the liver to the diaphragm.

The **round ligament** is the obliterated left umbilical vein, and is contained within the posterior or free edge of the falciform ligament. (Fig 64).

FISSURES

- The **longitudinal fissure** divides the organ descriptively into right and left lobes; it is separated into two parts by its union with the porta hepatis.

The *anterior* part or **fissure for ligamentum teres** contains the remains of the umbilical vein, and lies between the left lobe and the quadrate lobe. The *posterior* part or **fissure for ligamentum venosum** lies between the left lobe and the caudate lobe, and contains the remains of the ductus venosus.

The **porta hepatis** is placed at right angles to the longitudinal fissure, between the quadrate and the caudate lobes, and lodges the hepatic ducts, artery, and portal vein, nerves and lymphatics. The ducts are in front of the branches of the artery, and the branches of the portal vein are posterior.

The **fissure for the inferior vena cava** is placed obliquely at the posterior margin of the liver, behind the gall bladder, lying between the right lobe and the caudate lobe, and is separated from the porta hepatis by the caudate process. The hepatic veins

enter the vena cava at the bottom of this fissure. *They have no extra-hepatic course.* (Fig. 64).

LOBES

Right and left lobes are separated from each other by the fissure for ligamentum teres on the under surface, and posteriorly by the fissure for the ligamentum venosum. The right is the larger, and contains the porta hepatis and fissure for the inferior vena cava; is subdivided into the three following lobes:

The **quadrate lobe**: Bounded by the fissure for ligamentum teres and porta hepatis, and the fossa for the gall bladder.

The **caudate lobe** is on the posterior surface, and is the projection between the fissures for the inferior vena cava and ligamentum venosum, behind the porta hepatis.

The **caudate process** connects the preceding lobe with the main mass of the right lobe, and lies behind the porta hepatis.

Note on lobes: Above old-fashioned division into "right" and "left" lobes is descriptive only—actually vascular input and bile output are in two equal halves. Quadrate lobe and most of caudate lobe belong functionally to *left* half of liver.

FOSSA

The **fossa for the gall bladder** lies on the under surface of the right lobe, parallel to the fissure for ligamentum teres, and separates the quadrate lobe from the main mass of the right lobe.

THE GALL BLADDER AND BILE DUCTS

The **gall bladder** is a conical bag placed in a fossa on the under surface of the right lobe of the liver. Its long axis is directed *upwards, backwards, and to the left*, from the fundus to the neck. Its upper surface is attached to the liver, and its fundus and inferior surfaces are invested by peritoneum reflected from the adjacent surface of the liver.

Relations: The body is in contact in front with the liver and behind with the 1st part of duodenum and the right flexure of colon. The fundus is in contact with the parietes opposite the 9th right costal cartilage.

• The **cystic duct** passes from the neck of the gall bladder downwards, backwards, and to the left, to join the hepatic duct at or below the porta hepatis.

The **common hepatic duct**, formed by union of ducts from right and left lobes, issues from the liver at the porta hepatis. It joins the cystic duct, the two forming the *common bile duct*. Its length is 1 inch, and it lies entirely within the portal fissure.

• The **common bile duct** results from the union of the common hepatic and cystic ducts. It passes downwards in front of the opening of the lesser sac between the layers of the lesser omentum, having the portal vein behind and the hepatic artery on the left. It then descends behind the 1st part of the duodenum, and, passing between the pancreas and 2nd part of the duodenum, where it lies on the inferior vena cava, it enters the small intestine obliquely, a little below the middle of the second part of the duodenum, by an opening on the duodenal papilla (see p. 334) common to it and the pancreatic duct. Length, 3 inches, first inch in lesser omentum, second inch behind 1st part of duodenum, third inch behind or in head of pancreas.

VESSELS OF THE LIVER

The **hepatic artery** from the coeliac artery enters the porta hepatis and divides into two branches for the right and left lobes. The right branch runs behind the cystic duct, gives off the cystic artery to the gall bladder.

The **portal vein**, having in front the hepatic artery on the left and the bile duct on the right, ascends between the layers of the lesser omentum, in front of the opening of the lesser sac, to the porta hepatis. The portal vein and hepatic artery break up into *perilobular* vessels from which blood passes into the sinusoids within the lobules. The blood is then collected in the centre of the lobules by the *intra-lobular* veins, which are tributaries of the hepatic veins collecting blood from the liver.

The **hepatic veins** pass out of the liver at the bottom

of the fissure for the inferior vena cava, immediately joining that vessel. There are three, a central and two lateral.

THE PANCREAS

Consists of a body, enlarged to the right at its head, with which the body is connected by a narrow part or neck, and narrowed to the left, where it ends as the tail at hilum of spleen.

Position : Placed in the epigastric and left hypochondriac regions, directed nearly horizontally across posterior wall of abdomen.

Relations of the body :

Superior surface . Stomach and lesser omentum, covered by peritoneum.

Posterior surface : Aorta, crura of diaphragm, superior mesenteric vessels, splenic vein, left kidney, left suprarenal gland and left renal vessels.

Superior border : From right to left; coeliac artery, splenic artery.

Inferior surface : From right to left; duodeno-jejunal flexure, left flexure of colon, and small intestines, covered by peritoneum.

Left end or tail : Touches lower part of medial surface of spleen.

Right end or head : Embraced by three parts of duodenum, from which it is partly separated, behind by bile duct and in front by pancreatico-duodenal arteries. Is covered in front by transverse colon; posteriorly the *uncinate process* is a flange which projects to the left behind the superior mesenteric vessels. Behind are inferior vena cava and right renal vessels.

Neck : Extends from front of head forwards and to left to merge into body; behind the neck is the junction of the superior mesenteric with the splenic vein, forming the portal vein.

Pancreatic duct : Extends transversely from left to right, opens into 2nd part of the duodenum in common with the bile duct.

Accessory pancreatic duct : Drains from lower part of head and opens independently into duodenum above duodenal papilla. It may or may not communicate with the principal duct.

Arteries : Pancreatic of splenic, superior pancreatico-duodenal of hepatic, and inferior pancreatico-duodenal of superior mesenteric.

Veins : Open into splenic and superior mesenteric.

Nerves : From the cœliac plexus. Contains many lamellated (Pacinian) corpuscles.

THE PERITONEUM

The **peritoneum** is the serous membrane of the abdominal cavity. It consists of a *parietal* layer lining the abdominal and pelvic walls, and a *visceral* layer reflected more or less over the contained organs. In the male it is a closed sac, but in the female the free extremities of the uterine tubes open into the cavity. *Its disposition can best be learned by tracing its continuity in the un.injected cadaver.*

Commencing at the middle line and passing horizontally, the peritoneum lines the right half of the abdominal wall, as far as the lumbar region, where it entirely surrounds the cæcum and vermiform appendix. It invests only the front and sides of the ascending colon, though occasionally the whole circumference of the gut is enclosed, a mesocolon being then formed. The peritoneum then passes medially, covering the lower part of the anterior surface of the right kidney, the front of the 3rd part of duodenum, and goes downward over the front of the vessels of the small intestines, encloses the small intestines, and is reflected upwards on the posterior surface of the vessels to the spine, thus forming the *mesentery*. From the spine it may be traced to the left over the lower part of the anterior surface of the left kidney to the descending and pelvic colon, and thence on to the abdominal parietes to the middle line. The descending and iliac colon are invested in a similar manner to the ascending.

The peritoneum of the pelvis is continuous with that of the abdominal cavity. It encloses completely the pelvic colon, and forms the *pelvic mesocolon*. It is applied to the front and sides, and lower down to the front only of the rectum, whence it is reflected in the male on to the base and upper part of the bladder, forming the *recto-vesical pouch*; this is bounded on each side by the peritoneum reflected forwards from the sides of the rectum over the obliterated umbilical artery and ureter, forming the *posterior false ligament* of the bladder.

From the apex of the bladder the peritoneum passes upwards on to the anterior abdominal wall, enclosing the remains of the urachus and constituting the *median umbilical fold* of the bladder; whilst laterally it is reflected from the bladder along the line of the obliterated umbilical artery to the sides of the pelvis, forming the *lateral umbilical fold*. Where the obliterated umbilical artery passes between the abdominal wall and the side of the bladder it raises the peritoneum into a fold, which separates two shallow fossæ, the *medial* and *lateral inguinal fossæ*, which correspond in position to the superficial and deep inguinal rings.

In the female the peritoneum is reflected from the sides and front of the rectum to the upper part of the posterior wall of the vagina, and thence over posterior, upper, and anterior surfaces of the uterus to the bladder. Between the uterus and rectum is the *recto-uterine pouch* (of Douglas), corresponding to the *recto-vesical pouch* in the male. The peritoneum passes off from the lateral margins of the uterus to the pelvic wall, forming the *broad ligaments*, in the upper border of which the uterine tubes run, the peritoneum being continuous with their open fimbriated extremities. Free upper margin of broad ligament lateral to uterine tubes forms the *infundibulo-pelvic fold*.

In the upper part of the abdomen the peritoneum is attached to the under surface of the diaphragm as far backwards as the posterior surface of the liver, and the cardiac orifice of the stomach. It is then reflected forwards on the upper surface of the liver, forming

the ligaments of that organ; and passing round the anterior border it is applied to the under surface as far as the porta hepatis, where, meeting a peritoneal layer from the posterior surface (from the lesser sac), the two descend to the stomach to form the lesser omentum. Tracing it to the right from the longitudinal fissure, it invests the gall bladder, under surface of the right lobe, and the front of the 2nd part of the duodenum, passing to the anterior surface of the right kidney, where it becomes continuous with the part already traced. To the left of the longitudinal fissure the peritoneum covers the left lobe of the liver, and is reflected over the front of the cardiac end and fundus of the stomach, whence it passes off to invest the spleen, forming a reduplication, the *gastro-splenic ligament*. From the spleen it is continued over the anterior surface of the left kidney, forming the posterior layer of the *lienorenal ligament*, and over the descending colon to join the part already described.

Between the liver, stomach, and transverse colon is a diverticulum of the main peritoneal sac, which communicates with the larger peritoneal cavity through the *opening into the omental bursa (lesser sac)*. To understand the disposition of the layers one has to imagine the smaller sac to have been invaginated through the opening into lesser sac inwards and behind the stomach.

The Two Sacs traced Vertically

From porta hepatis two layers pass

To lesser curvature of stomach, where they separate, one passing in front and the other behind stomach, thus enclosing it.

These layers join together again at greater curvature, forming anterior layers of greater omentum.

Pass down in front of and beyond transverse colon.

Bend upwards and backwards, and separate to enclose transverse colon; continue together to the posterior abdominal wall, until opposite the lower border of the pancreas, where they part, one layer passing upwards and the other downwards.

The *ascending layer* passes:

Over upper surface of pancreas and posterior part of diaphragm.

Then on to posterior surface of liver to the porta hepatis.

The *descending layer* passes:

Along superior mesenteric vessels, round jejunum and ileum, and back to spine, forming mesentery.

Downwards in front of spine, lower part of aorta and sacral promontory.

Over pelvic colon, forming pelvic mesocolon.

Forwards:

Male—To bladder, forming recto-vesical pouch and posterior false ligaments (p. 345).

Female.—To vagina and uterus, forming posterior ligaments of uterus and recto-vaginal pouch.

Then over uterus to bladder, forming utero-vesical pouch and posterior vesical ligaments

Over bladder to anterior abdominal wall, covering urachus and obliterated umbilical arteries as far as umbilicus.

Over under surface of diaphragm.

Reflected over upper surface of liver.

Round anterior border of liver to under surface as far as porta hepatis.

The Two Sacs traced horizontally, at the Level of the Opening into Lesser Sac

From falciform ligament of liver:

Over anterior abdominal wall and diaphragm

Over lateral part of left kidney.

Reflected laterally behind splenic vessels to spleen, forming posterior layer of lienorenal ligament.

Over spleen as far as hilum.

To stomach, forming anterior layer of gastro-splenic ligament.

Over anterior wall of stomach into anterior layer of lesser omentum.

Turns round common bile duct, forming anterior edge of opening into lesser sac (here the smaller sac commences).

Passing from right to left:

" Forms posterior layer of lesser omentum.
Over posterior surface of stomach.

Forms posterior layer of gastro-splenic ligament, reaching hilum of spleen.

Forms anterior layer of lienorenal ligament.

Passing now from left to right:

Continues over left kidney, aorta, and inferior vena cava, here forming posterior boundary of opening into lesser sac (here smaller sac ends, and large sac again commences).

Over right kidney to liver.

Over under surface of liver to right border, round which it may be traced over anterior surface, to falciform ligament.

"

SYNOPSIS OF PROCESSES OF THE PERITONEUM

Omenta : Folds of two layers connected with the stomach.

Lesser omentum : From porta hepatis and fissure for ligamentum venosum on liver to lesser curvature of stomach and 1st part of duodenum. Right border free, forming anterior boundary of opening into lesser sac. Left border attached to diaphragm between oesophageal and caval orifices.

Greater Omentum : Formed, as shown above, by the passing downwards and then folding upwards of the two layers passing from stomach, and thus encloses the lower part of the cavity of the smaller sac of the peritoneum. Spleen projects into its left leaf.

Mesenteries : Folds connecting intestine to posterior abdominal wall and containing between their layers the bloodvessels of the intestine.

The mesentery : Attached behind to left side of 2nd lumbar vertebra (duodeno-jejunal flexure) passing downwards across vertebrae to right sacro-iliac joint. Contains lymphatics, superior mesenteric vessels, jejunum and ileum between its layers. The upper layer is continuous with inferior layer of transverse mesocolon, the lower layer with peritoneum on posterior abdominal wall.

Transverse mesocolon : Formed by junction of two ascending layers of greater omentum after they have enclosed transverse colon; at the attachment posteriorly the two layers separate, as explained, into ascending and descending layers (p. 347).

Pelvic mesocolon : A long process attached to left brim of pelvis and upper half of hollow of sacrum.

Ligaments : The peritoneum, as explained, is reflected from the abdominal walls to viscera, forming so-called ligaments

Ligaments of the liver :

Falciform : Sickle-shaped fold passing from anterior abdominal wall to upper and anterior surfaces of liver. The inferior free border contains obliterated umbilical vein or round ligament of liver

Coronary : Connects right lobe to diaphragm; consists of two layers, the anterior being derived from greater sac and the posterior from lesser sac.

Triangular (2) : These are the right and left ends of the coronary ligament.

Ligaments (false) of the bladder :

Posterior false ligaments (2) : The edges of the recto-vesical pouch (sacro-genital folds)

Lateral umbilical folds (2) : Reflections from sides of bladder along obliterated umbilical arteries.

Median umbilical fold : Reflection from bladder to anterior abdominal wall along urachus

Ligaments of the uterus :

Broad ligaments (2) : Each passes from side of uterus to lateral pelvic wall; contains between its folds the round ligament of uterus, uterine tube, the ovary and its ligament, and branches of ovarian and uterine vessels

Anterior ligaments (2) : Margins of utero-vesical pouch.

Recto-uterine folds (2) : Margins of recto-vaginal pouch.

Infundibulo-pelvic ligament : The upper part of the lateral margin of the broad ligament. Extends from infundibulum of tube and upper or tubal end of ovary to the lateral pelvic wall; in its free lateral

margin are the ovarian vessels, nerves and lymphatics.

Lieno-renal ligament : Passes from left kidney to spleen; the right or anterior layer is formed by the lesser sac, and the left or posterior by the larger one. Contains splenic vessels and tail of pancreas between its layers.

Gastro-splenic omentum : Passes from fundus of stomach to hilum of spleen, and contains the left gastro-epiploic and short gastric vessels between its layers. Below it is continuous with the great omentum.

Phrenico-colic ligament (see p. 337)

The *opening into lesser sac* is the orifice behind the free margin of the lesser omentum, by which the smaller peritoneal sac communicates with the general peritoneal cavity.

Relations :

<i>Anterior.</i>		<i>Posterior.</i>	<i>Superior.</i>	<i>Inferior.</i>
Bile duct	{ Between the layers of the lesser omentum.	Inferior vena cava.	Caudate process.	1st part of duodenum.
Hepatic artery		Right crus of diaphragm.		Commencement of hepatic artery.
Portal vein				

The Respiratory System

THE NOSE

External nose : Bony margins are nasal bones and frontal process of maxilla. Completed by *upper* and *lower nasal cartilages*, supported by *septal cartilage*. Ala of nose is movable, contains *small cartilages*.

CAVITY OF NOSE

The *nasal cavities*, separated from each other by the septum, open in front by the nostrils and behind by posterior apertures of nose. Each cavity possesses a roof, floor, medial and lateral walls.

The *roof*, which is highly arched, is formed by the nasal bones, nasal spine of frontal, cribriform plate of ethmoid, under surface of body of sphenoid, ala of vomer, and sphenoidal process of palatine bone.

The *floor* consists of palatine process of maxilla and horizontal plate of palatine bone.

The *medial wall (nasal septum)* is made up of cartilage of septum, crest of nasal bones, nasal spine of frontal, perpendicular plate of ethmoid, vomer, rostrum of sphenoid, and crests of maxillæ and palatine bone.

The *lateral wall* is formed by frontal process of maxilla, lacrimal bone, ethmoid, nasal surface of maxilla, inferior nasal concha, perpendicular plate of palatine bone and medial pterygoid plate of sphenoid.

The *posterior apertures of nose* open backwards into the naso-pharynx. They are oval in shape, being about 1 inch vertically and $\frac{1}{2}$ inch transversely.

Meatuses : Superior and middle nasal conchæ of

ethmoid and inferior nasal concha project into nasal cavity from its lateral wall. Divide lateral wall into four recesses: sphenoid-ethmoidal recess above superior concha, superior, middle and inferior meatuses *below* their corresponding nasal conchæ.

Openings : (Fig. 65).

Spheno-ethmoidal recess : Sphenoidal sinus.

Superior meatus : Posterior ethmoid cells.

Middle meatus : Contains *bulla of ethmoid* (formed

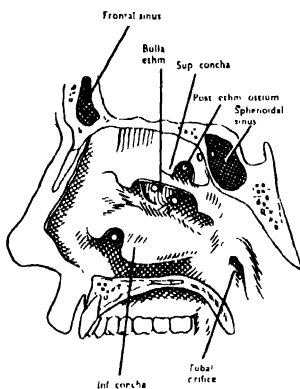


FIG. 65.—THE LATERAL WALL OF THE NOSE, THE CONCHÆ PARTLY REMOVED TO DISPLAY THE OPENINGS.

by middle ethmoid cells, which open on it) and *hiatus semilunaris*, which receives infundibulum of frontal sinus and anterior ethmoid cells in front and maxillary sinus behind.

Inferior meatus : Naso-lacrimal duct.

Paranasal sinuses : Through the above openings mucous membrane of nose communicates with paranasal sinuses in the neighbouring bones. Each sinus is lined with ciliated columnar epithelium; direction of ciliary currents is spirally towards opening of sinus.

Sphenoidal sinus : Formed before birth by

sphenoidal conchæ. Enlarges by excavation of body of sphenoid. Has hypophysis cerebri (pituitary gland) above it and cavernous sinus laterally. Late in life may extend into basi-occiput.

Ethmoidal sinuses : Anterior, middle and posterior, they are roofed in by the frontal bone. Lie in *medial wall of orbit*. Anterior may open into infundibulum of frontal sinus or directly into hiatus semilunaris, others as stated above.

Frontal sinus : Absent until end of first year. When fully developed lies in vertical and orbital plates of frontal bone, forming antero-medial part of *roof of orbit*. Usually asymmetrical. Open into middle meatus by funnel-shaped *infundibulum*.

Maxillary sinus : Its roof is *floor of orbit*, its floor is roof of mouth (alveolar process). Extends to lower level than floor of nose. Maxillary teeth from first bicuspid to last molar lie in floor.

Mucous membrane : On the lateral wall and septum is divided into upper olfactory and lower respiratory parts. Olfactory part consists of mucosa over superior and upper part of middle nasal concha, corresponding part of septum, and roof of nose; remainder is respiratory.

The epithelium covering the surface consists of three varieties:—

1. *Stratified squamous*, in the vestibule of nose.
2. *Columnar*, in the olfactory region.
3. *Ciliated columnar*, in the respiratory region and paranasal sinuses.

Sensory nerves of nose : Carry also parasympathetic (secreto-motor) fibres to mucous glands and paranasal sinuses, mostly from pterygo-palatine (sphenopalatine) ganglion.

Septum : Supplied postero-inferiorly by nasopalatine (long sphenopalatine) nerves, which groove vomer and pass through incisive canal of maxilla to front of hard palate. Antero-superiorly supplied by medial branch of anterior ethmoidal (from naso-ciliary of 5th cranial).

Lateral wall : Supplied in quadrants; upper anterior by lateral branch of anterior ethmoidal, lower anterior by anterior superior alveolar (dental), upper posterior by posterior superior nasal (short sphenopalatine) and lower posterior by nasal branches of greater palatine.

Roof of naso-pharynx : By pharyngeal branch of pterygo-palatine (sphenopalatine) ganglion, passing back in palatino-vaginal canal.

The olfactory nerve : From the olfactory mucous membrane the olfactory nerves pass through the cribriform plate of ethmoid to reach the olfactory bulb.

Vessels of nose : Facial artery supplies antero-inferior part of lateral wall, greater palatine antero-inferior part of septum; otherwise vessels accompany sensory nerves already described.

THE LARYNX

The **larynx** lies in the front and upper part of the neck, being placed below the tongue and hyoid bone and between the large vessels of the neck. It opens above into the pharynx and below into the trachea. In the middle line it is covered only by skin and cervical fascia; but laterally it is overlaid by the sterno-hyoid and sterno-thyroid, by the thyro-hyoid and origin of the inferior constrictor. Is composed of cartilages held together by ligaments, and moved by muscles, the whole being lined with mucous membrane.

The **cartilages** of the larynx:

The **thyroid** cartilage is the largest; consists of two laminae united in front at an acute angle, and forming the projection known as the laryngeal prominence (Adam's apple).

Outer surface : Shows *oblique line*, passing upwards and backwards, giving attachment to sterno-thyroid and thyro-hyoid muscles, and below oblique line to inferior constrictor.

Inner surface : Presents in the middle line at the junction of right and left alae, the *angle*, to which are attached the root of the epiglottis, the ventricular

and vocal folds, the thyro-arytenoid and thyro-epiglottic muscles.

Superior border : Sinuous; connected to hyoid bone by thyro-hyoid membrane; the two borders meeting together anteriorly in the mid-line form thyroid notch above laryngeal prominence.

Inferior border : Near mid-line, connected with upper border of cricoid by crico-thyroid ligament, and by crico-thyroid muscle laterally.

Posterior border . Thick and rounded, receives insertion of stylo-, salpingo- and palato-pharyngeus muscles, prolonged upwards into *superior horn*, which passes upwards, backwards, and medially, having lateral thyro-hyoid ligament attached to tip; and downwards into *inferior horn*, shorter, passing downwards, forwards, and medially, presenting on medial surface a small facet which articulates with the cricoid by a synovial joint.

The **cricoid cartilage** : Shaped like signet ring, deep behind (*lamina*) and shallow in front (*arch*).

Outer surface : Anterior half gives attachment to crico-thyroid muscles, and behind this to crico-pharyngeus part of inferior constrictor. Posterior half, broad and thick, presents ridge in middle line for attachment of some longitudinal fibres of œsophagus; on each side of ridge, a depression giving attachment to the posterior crico-arytenoid. At junction of arch and lamina a small facet for articulation with inferior horn of thyroid cartilage.

Inner surface : Smooth, lined with mucous membrane

Superior border : Inclines from the front, upwards and backwards, gives attachment anteriorly to the crico-thyroid ligament, and laterally to crico-vocal membrane and lateral crico-arytenoid. Upper border of lamina has on each side an articular facet for arytenoid. Facet slopes downwards and laterally; downward pull of vertical fibres of posterior crico-arytenoid causes descent and therefore mutual separation of arytenoids along these sloping facets.

Inferior border . Horizontal; connected with 1st ring of trachea by crico-tracheal ligament.

Arytenoid cartilages : Are two small pyramidal cartilages, articulating with upper border of lamina of cricoid.

Antero-lateral surface : Convex and rough, receives attachment of thyro-arytenoid muscle and vestibular fold.

Posterior surface : Hollowed for attachment of transverse arytenoid muscle.

Medial surface : Narrow and smooth, covered with mucous membrane.

Base : Has concave facet on under surface which articulates with the cricoid cartilage, forming a gliding synovial joint.

Muscular process : The lateral angle gives attachment to lateral and posterior crico-arytenoid muscles.

Vocal process : The anterior angle, long and pointed, gives attachment to vocal fold (vocal cord).

Apex : Looks backwards and medially, surmounted by the corniculate cartilage.

Corniculate cartilage : A small cartilage of conical shape, attached to the apex of each arytenoid cartilage, and giving attachment to the ary-epiglottic fold.

Cuneiform cartilage : A small cartilage, one on each side, found in the ary-epiglottic fold.

The **epiglottis** covers the superior aperture of the larynx; it is a leaf-shaped lamina of yellow elastic cartilage.

Apex : Attached to angle of thyroid by *thyro-epiglottic ligament*.

Base : Broad, rounded, and free; directed upwards.

Anterior surface : Covered in upper part by mucous membrane, which passes forwards as the *median glosso-epiglottic fold* on to the tongue; laterally the *lateral glosso-epiglottic (pharyngo-epiglottic) folds* pass on to the pharyngeal wall; below it is attached to the hyoid bone by *hyo-epiglottic ligament*.

Posterior surface : Covered by mucous membrane, concave from side to side, concavo-convex from above downwards; the convex part is known as the *tubercle* or *cushion* of the epiglottis.

The **LIGAMENTS and MEMBRANES** of the larynx are:

The **thyro-hyoid membrane**: Thickened in the mid-line as the *median thyro-hyoid ligament*, passes from the upper border of the thyroid cartilage to the upper border of the posterior surface of the hyoid bone; between it and the posterior surface of the body of the hyoid bone is a synovial bursa. It forms the base of the piriform fossa and is pierced by the superior laryngeal vessels and internal laryngeal nerve of each side.

The **lateral thyro-hyoid ligament**, the posterior edge of the preceding, passes from the superior horn of the thyroid to the tip of the greater horn of the hyoid bone. In it is found a small cartilaginous nodule, the *cartilago triticea*.

The **crico-vocal membrane** (*conus elasticus*) is attached below to the upper border of the cricoid arch. Above, it is attached anteriorly to the deep surface of the fused ala of the thyroid cartilage constituting the crico-thyroid ligament, and, posteriorly, to the vocal process of the arytenoid. Between these attachments its border is free and constitutes the **vocal ligament** (*plica vocalis*).

The **quadrate membrane** encloses the vestibule and separates it from piriform fossa of pharynx. Attached anteriorly to margin of lower half of epiglottis and posteriorly to corniculate cartilage and vocal process of arytenoid. Short lower margin free, forms ventricular fold ("false cord"). Long upper margin also free, forms ary-epiglottic fold.

THE INTERIOR OF THE LARYNX

The **inlet** of the larynx is the oval, nearly vertical communication with the pharynx. It is bounded in front by the epiglottis, behind are the summits of the arytenoid cartilages and corniculate cartilages, and, laterally, the ary-epiglottic folds.

The **cavity** of the larynx extends from the inlet to the lower border of the cricoid cartilage. It is divided into three parts by two projecting folds on either side: the ventricular and vocal folds (false and true vocal cords). The part above the ventricular folds is the

vestibule. The space between the vocal folds is the *rima glottidis*.

The whole is covered by mucous membrane; over the true cords this is lined by stratified squamous epithelium, but below this it is columnar ciliated.

The **vocal fold (true vocal cord)**, one on each side, is attached in front to the angle of the thyroid cartilage, and behind to the anterior or vocal process at the base of the arytenoid cartilage. It consists of the upper free edge of the crico-vocal membrane covered by firmly adherent stratified squamous epithelium.

The **ventricle** of the larynx is the fossa between the ventricular and vocal folds; the anterior part of each is prolonged upwards between the vestibular fold and the lamina of the thyroid cartilage into a pouch, the **sacculæ**.

The **arteries** of the larynx are the laryngeal branches of the superior and inferior thyroid, supplying above and below vocal folds respectively.

Nerves—*Internal laryngeal*: Supplies mucous membrane above true vocal cords.

* *Recurrent laryngeal*: Supplies muscles (except crico-thyroid) and mucous membrane below vocal folds.

External laryngeal: Supplies crico-thyroid muscle.

THE INTRINSIC MUSCLES OF THE LARYNX (see Fig. 66)

Crico-thyroid—*Origin*: Lateral surface of cricoid cartilage.

Insertion: Lower border of ala of thyroid and front of inferior cornu.

Action: Elongator of cords

Thyro-arytenoid—*Origin*: Inside thyroid cartilage, from junction of alæ just lateral to attachment of vocal cord. Lies in vocal fold.

Insertion: Lateral surface of arytenoid.

Action: Shortens cords.

Posterior crico-arytenoid—*Origin*: Oval area on either side of mid-line on back of cricoid.

Insertion: Muscular process of arytenoids,

Action : Abductor of cords. In man this is chiefly by drawing arytenoids down (and therefore apart) along the sloping facets on cricoid lamina; very slight rotary effect on arytenoids aids in enlarging rima glottidis. In many animals rotary movement predominates.

Lateral crico-arytenoid—*Origin :* Upper border of lateral part of cricoid.

Insertion : Muscular process of arytenoid.

Action : Adduction of cords by rotation forwards of muscular process.

Transverse arytenoid—*Origin :* Back of one arytenoid.

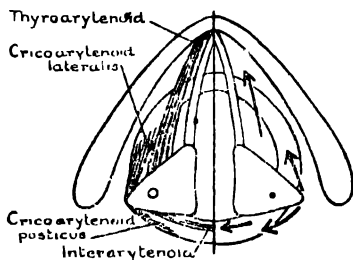


FIG. 66 — DIAGRAMMATIC PLAN OF LARYNX TO SHOW INTRINSIC MUSCLES.

The left side shows the muscles; the arrows on the right side indicate their actions (see summary below).

Insertion : Back of other arytenoid.

Action : Approximates arytenoids, adducting the cords.

Ary-epiglottic muscle : Posterior to transverse arytenoid.

Origin : Back of arytenoid.

Insertion : Side of epiglottis on opposite side, becoming attached to corniculate and cuneiform cartilages.

Action : Sphincter; closes aperture of larynx by approximating arytenoids to tubercle of epiglottis.

All these are supplied by nucleus ambiguus, the

crico-thyroid via external laryngeal nerve, and the others via recurrent laryngeal.

SUMMARY

1. Cords lengthened by crico-thyroid, shortened by thyro-arytenoid. *Tension* of cords is a function of the tonus of thyro-arytenoid.
2. Cords opened by posterior crico-arytenoid, whose upper horizontal fibres rotate arytenoids (Fig. 66) and whose vertical fibres separate arytenoids bodily from each other (p. 355). Cords closed by lateral crico-arytenoids (opponent of rotary fibres of posterior crico-arytenoid) and transverse arytenoid (opponent of vertical fibres of posterior crico-arytenoid).
3. Inlet of larynx closed by ary-epiglottic muscles.

THE TRACHEA

The trachea extends from the lower border of the larynx (opposite the lower border of 6th cervical vertebra) to the level of the 5th thoracic vertebra, there dividing into the two bronchi. In length it measures $4\frac{1}{2}$ inches.

The tube is extensible, being made of fibro-elastic tissue, and it is kept from collapsing during inspiration by hyaline cartilages.

The *cartilages*, from sixteen to twenty in number, are U-shaped, open posteriorly; the posterior free ends are connected by unstriped muscle (*trachealis muscle*).

The trachea is lined by respiratory mucous membrane (containing mucous and serous glands) and lined with ciliated columnar epithelium.

Blood supply is by the inferior thyroid artery, which carries sympathetic fibres from middle cervical ganglion. Parasympathetic supply is via both recurrent laryngeal nerves and right vagus.

Relations: *In the neck* these are symmetrical. Clasped laterally by lobes of thyroid gland down to 6th ring, carotid sheaths below this. Isthmus of thyroid gland adherent over 2nd, 3rd and 4th tracheal rings. Pretracheal fascia, containing inferior thyroid

plexus of veins, covers it below isthmus. Posteriorly lies the œsophagus, with recurrent laryngeal nerves in the groove between the two. *In the thorax*, asymmetrical. On left, apex of lung and vagus separated by arch of aorta and its branches (left common carotid and subclavian). On right, vagus and right apex in contact—at lower extremity azygos vein arches over vagus and trachea to enter superior vena cava. Left recurrent laryngeal nerve in tracheo-œsophageal groove. (Esophagus lies in contact with trachealis muscle in both neck and superior mediastinum)

The *right bronchus*, less than 2 inches long, is shorter, more vertical in direction (25 degrees), and of larger calibre than the left. It passes to the root of the corresponding lung, lying at first above and then behind the right pulmonary artery. Before reaching the pulmonary artery it gives off a branch to the upper lobe of the right lung, the *upper lobe bronchus*, and the vena azygos arches forwards above it.

The *left bronchus* is more than 2 inches long, and passes downwards (at 45 degrees) under the arch of the aorta to the root of the left lung, joining it at the level of the upper border of 6th thoracic vertebra. Behind it are the œsophagus, thoracic duct, and descending aorta. It lies at first behind the bifurcation of the pulmonary trunk, and then below the left pulmonary artery.

THE LUNGS AND THE PLEURÆ

The *lungs*, two in number, occupy the whole of the thorax except the mediastinum, which separates them from each other. They are conical in shape, and are covered with pleura. Each lung is free except at the median part or root, where it is attached to the blood vessels and bronchi.

The *pleuræ* are two serous sacs enclosing and investing the lungs. Each pleura consists of visceral and parietal layers. The *visceral* layer covers the lung, and the *parietal* layer lines the inner surface of the chest-wall, the upper surface of the diaphragm,

and the sides of the pericardium and superior mediastinum. The visceral layer of each pleura becomes continuous with the parietal layer in front and behind the root of the lung; and below the root a fold, the *pulmonary ligament*, extends downwards along the medial surface of the lung. It provides a "dead space" for distension of the pulmonary veins.

Surface-marking of pleuræ: The limits of the parietal pleuræ are as follows: Each extends upwards above the medial end of the clavicle for more than an inch. This is a measure of the obliquity of the thoracic inlet, and marks the upward projection of the inner border of the first rib. From this each pleura passes downwards and forwards to the posterior aspect of the sterno-clavicular joint and meets its fellow in the mid-line at the manubrio-sternal articulation; they pass down together to level of 4th costal cartilages, where the *right pleura* passes vertically to level of 6th right costal cartilage in mid-line; then laterally, crossing 10th rib in mid-axillary line; then backwards along 11th rib to reach spine at neck of 12th rib. At level of 4th costal cartilage the *left pleura* arches laterally, leaving part of anterior surface of pericardium uncovered, and lying about $\frac{1}{2}$ inch from the left margin of sternum, to reach 7th left costal cartilage, below which it follows same line as on right, but is placed at a slightly lower level.

NOTE.—Projection of pleura above medial end of clavicle and first rib is due to obliquity of thoracic inlet; apex of lung does not project out of inlet when viewed from the side.

THE LUNGS (Fig. 67)

Each lung is cone-shaped, with the base downwards. The apex projects upwards behind the medial $\frac{1}{2}$ of clavicle and anterior scalene muscle (see note above). Above the first rib, the first part of the subclavian artery lies in front, being separated from it by the pleura.

The base is concave, resting upon the diaphragm.

The costal surface is convex, and corresponds to the chest wall.

The *medial surface* is concave, corresponding in part to the convex outer surface of the pericardium. It presents about its middle, and towards the posterior part, a slit, the *hilum of the lung*, where the bronchi and vessels pass in to form the root.

The *anterior border* is thin, and overlaps the pericardium, and presents on the left side a notch produced by the heart (*cardiac notch*).

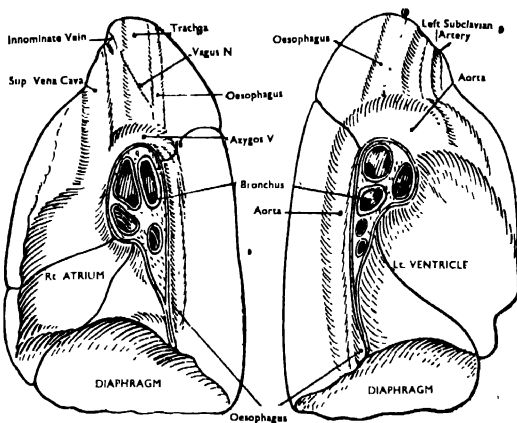


FIG. 67.—THE MEDIASTINAL SURFACES OF THE LUNGS, SHOWING THE MARKINGS MADE BY THE MEDIASTINAL STRUCTURES.

The *posterior border* is rounded, and occupies the groove by the side of the vertebræ.

Fissures and Lobes : The left lung is smaller and narrower than the right, and is divided into an upper and lower lobe by a fissure, which passes upwards and backwards from the anterior border nearly to the root. Small tongue of upper lobe between this fissure and the cardiac notch is known as the *lingula*. It corresponds with the middle lobe of the right lung. The right lung is larger and shorter than the left, and is divided into three lobes (upper, middle, and lower) by two fissures. One fissure passes obliquely from the

costal surface upwards and medially nearly to the root, and the second passes horizontally from the middle of the first, forwards to the anterior border, cutting off a middle triangular lobe.

The **roots** contain the bronchi, pulmonary arteries and veins. Here lie also the pulmonary plexuses, bronchial arteries and veins and the hilar lymph glands. Disposition of bronchi and pulmonary vessels in cut surface depends on level of section (see Fig. 68). On *right*, bronchus to upper lobe stems from right main bronchus outside lung root. On *left*, undivided bronchus enters the lung. Pulmonary artery lies above each bronchus, then spirals down behind it. Upper and lower pulmonary veins lie lowest, just above closed fold of "pulmonary ligament" (Fig. 67).

The Bronchial Tree. *Main bronchus* supplies whole lung. Each *lobar bronchus* supplies a lobe. Right upper lobe bronchus branches from main bronchus

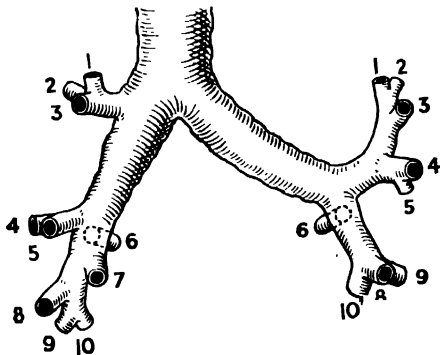


FIG. 68.—THE SEGMENTAL BRONCHI.

1. Apical. 2. Posterior. 3. Anterior. 4. Lateral on right, superior on left. 5. Medial on right, inferior on left. 6. Apical of lower lobe. 7. Medial basal. 8. Anterior basal. 9. Lateral basal. 10. Posterior basal.

outside lung. Middle lobe bronchus stems off within the lung. In left lung, upper lobe bronchus arises in common with bronchus to lingular lobe within the lung (lingular lobe is counterpart of right middle lobe).

Segmental bronchi. Each lobar bronchus gives off segmental bronchi. Upper lobe has three segments, their bronchi on the right being *apical*, *posterior* and *anterior*, all coming off together. On the left, upper lobe bronchus divides into *apico-posterior* and *anterior*, former quickly dividing into apical and posterior. Middle lobe has two segments. On the right these are lateral and medial. On the left lingular lobe has superior and inferior segments. Lower lobe has five segments. Apical bronchus to lower lobe is *first posterior branch* from bronchial tree (so inspired liquid, in recumbency, enters here). Lower lobe bronchus then aerates medial (small on left), anterior, lateral and posterior basal segments. (Fig. 68).

E MEDIASTINUM (Fig. 69)

The mediastinum is, strictly speaking, the septum between the two lungs, but the name is in general use for the space between the two pleural sacs; it extends from the sternum in front to the thoracic vertebrae behind, and from the thoracic inlet above to the diaphragm below.

For descriptive purposes it is divided into a superior and an inferior mediastinum, and the latter is again subdivided into anterior, middle, and posterior.

The superior mediastinum is the space above the pericardium extending upwards to the root of the neck.

Boundaries :

- Superior : Thoracic inlet.
- Inferior : Plane passing from lower border of body of 4th thoracic vertebra to the junction of the body and manubrium of sternum.
- Anterior : Manubrium and origins of sterno-hyoid and sterno-thyroid muscles.

Posterior : First four thoracic vertebræ, (and lower ends of longi cervicis.) 1, 2, 3, 4

Laterally : (The parietal or mediastinal pleura,) passing back from posterior surface of sternum to vertebræ. 5

Contents : Trachea (lower end), 6
 oesophagus, 7
 thoracic duct, 8
 arch of the aorta, 9
 innominate artery, 10
 thoracic part of left carotid and subclavian arteries, 11
 innominate *coeliacum* 12

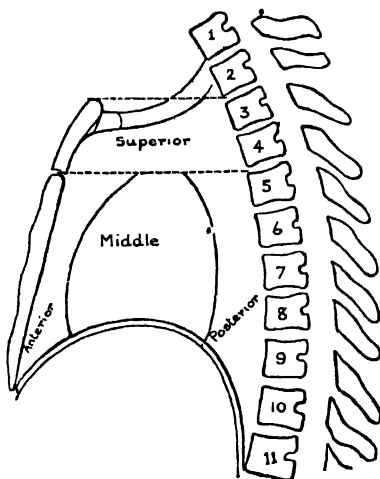


FIG. 69.—OUTLINE OF THE MEDIASTINA.

Note also the level of the top of the sternum ($T \frac{4}{5}$) and of the angle of Louis ($T \frac{8}{9}$) in terms of vertebræ.

ate veins, 13
 upper part of superior vena cava, 14
 both phrenic and vagus nerves, 15
 left recurrent laryngeal and the cardiac nerves, 16
 lymphatic glands and remains of thymus gland. 17

The **anterior mediastinum** is the space between the two pleuræ in front of the pericardium; it is narrow above, but broader below.

Boundaries :

Anterior : Sternum, with 5th, 6th, and part of 7th left costal cartilages, transversus thoracis (sternocostalis), and left internal mammary vessels.

Posterior : Pericardium.

Laterally : Pleura. (*mediastinal*)

Contents : Anterior mediastinal glands. Thymus.

The **middle mediastinum** contains the pericardium with its contents, the phrenic nerves and accompanying vessels, the arch of the vena azygos, the roots of the lungs and bronchial lymphatic glands.

✓ The **posterior mediastinum** lies behind the pericardium and diaphragm.

Boundaries :

Anterior : Pericardium and roots of lungs, and diaphragm (below).

Posterior : Vertebral column, from the lower border of the 4th to the 12th thoracic vertebra.

Laterally : Pleura. (*mediastinal*)

Inferior : Diaphragm.

Superior : Plane passing forwards from lower border of 4th thoracic vertebra.

✓ *Contents :* Descending thoracic aorta and some of its right intercostal branches, œsophagus, vagi and splanchnic nerves, the azygos and hemi-azygos veins, thoracic duct, and posterior mediastinal glands.

CHAPTER ELEVEN

The Urinary Organs

THE KIDNEYS (Fig. 70)

The kidneys secrete the urine, and are situated behind the peritoneum, extending from the 11th rib to within an inch of the iliac crest, the right being placed lower than the left. The average length of

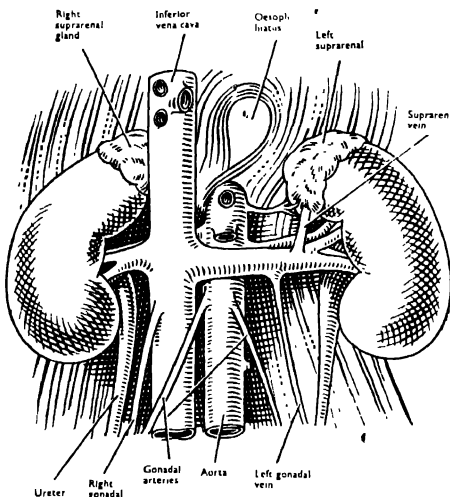


FIG. 70—THE POSTERIOR ABDOMINAL WALL WITH THE KIDNEYS IN POSITION.

each kidney is 4 inches, breadth $2\frac{1}{2}$ inches, and thickness $1\frac{1}{2}$ inches. Weight, $4\frac{1}{2}$ ounces. ▲

Relations : The relations of the two kidneys differ, somewhat; each is placed so that its anterior surface looks laterally and the posterior medially, the upper end being nearer the mid-line than the lower. Each kidney is partly covered on its anterior surface by peritoneum.

Relations of the Right Kidney.

Anterior.

Right lobe of liver.
2nd part of duodenum.
Right flexure of colon.
(Of which the last two areas are non-peritoneal.)
Coils of jejunum and right colic vessels.

Posterior.

Diaphragm, separating it from *pleura* (Fig. 71).
Quadratus lumborum.
Psoas.
Lumbar fascia.
12th thoracic
Ilio-hypogastric } **Nerves.**
Ilio-inguinal
Subcostal vessels.
12th rib.

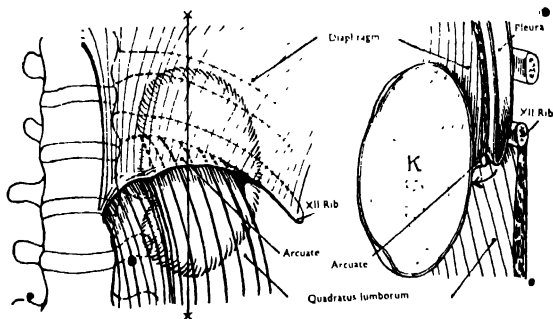


FIG. 71.—THE POSTERIOR RELATIONS OF THE KIDNEYS, WITH SPECIAL REFERENCE TO THE DIAPHRAGM AND PLEURA.

The right-hand diagram represents a vertical section along the line marked x——x in the left-hand diagram.

*Relations of the Left Kidney**Anterior.*

Fundus of stomach.
 Postero-medial surface of spleen.
 Tail of pancreas
 Descending colon
 (Of which last two are retro-peritoneal)
 Jejunum.
 Upper left colic vessels.

Posterior.

As on right, except that left kidney, lying rather higher, covers 11th rib

Above each kidney is the suprarenal gland.

The *lateral border* is convex, and is directed laterally and backwards.

The *medial border* is concave, directed well forwards, and at the centre is the fissure or *hilum*, where the vessels enter and the ureter leaves, lying from before backwards as follows: renal vein, renal artery, ureter. Renal artery usually divides and enters hilum as three vessels, two in front and one high up behind pelvis. Aberrant artery from aorta to lower pole very common.

Each kidney is surrounded by a loose connective tissue sheath (renal fascia) containing fat (renal fat)

THE URETERS

Each kidney is connected with the bladder by a ureter, 10 inches (25 cm.) long, which serves to convey urine to the latter viscus; the upper end of each ureter is expanded, as the *pelvis*, which is divided into two parts called *greater calyces*; these again are subdivided into about 12 *lesser calyces*. Into these calyces small *papillæ* project, which are the apices of the *renal pyramids*. These latter form the medullary substance of the kidney, and are embedded in the cortical substance, which encloses them completely except at the *papillæ*.

Capacity of pelvis about 5 ml.

Relations of the Ureter in the Abdomen

<i>Anterior.</i>	<i>Posterior.</i>
Peritoneum.	Psoas.
Colic vessels.	Genito-femoral nerve.
Testicular or ovarian vessels.	Common or external iliac artery.
Ileum and mesentery (right side).	
Pelvic colon and mesocolon (left side)	

The *right* ureter lies close to the lateral side of the inferior vena cava.

In the Pelvis

In the male. Each ureter enters the pelvis by crossing the bifurcation of the common iliac artery. It then runs down to the ischial spine, along a line immediately in front of the internal iliac artery, and crossing the obturator nerve, and the anterior branches of the internal iliac artery. It then turns medially to reach the bladder, and passes below the vas deferens just before entering the bladder.

NOTE.—Surface-marking (for radiographic identification): a line along the tips of the lumbar transverse processes to the spine of the ischium on to the pubic tubercle.

In the female: Course is as above, but the ureter crosses the side of the cervix below the uterine artery and lateral to upper part of vagina, to posterior part of base of bladder, and ends as in the male.

Narrowest parts of ureter are (1) pelvi-ureteric junction, (2) at brim of pelvis and (3) at entrance to bladder. Calculus may be impacted at one of these three places.

THE BLADDER

The **bladder** receives the urine from the kidneys by the ureters.

Position: In *infancy* it lies mostly in the abdomen. In the *adult* it lies in the pelvis behind the pubis; in the *male* in front of the rectum; in the *female* it is placed in front of the uterus and vagina.

The *apex* is connected to the umbilicus by the median umbilical ligament (*urachus*), and by the lateral umbilical ligaments, the part posterior to the urachus being covered with peritoneum.

The *body* is uncovered anteriorly by peritoneum, and in front are the symphysis and body of the pubis, medial pubo-prostatic ligaments and retropubic space. Superiorly it is covered by peritoneum in the upper part, and is in contact with the pelvic colon in the male, and uterus in the female, and with small intestines in both. Crossing obliquely on the side of the bladder (when distended) is the lateral umbilical ligament, which marks the lateral limit of its peritoneal covering; below this the bladder is separated by loose connective tissue from the obturator internus and levator ani. The vas deferens crosses obliquely the lower part of the lateral surface along the medial side of the ureter and lateral umbilical ligament.

The *base* is directed backwards and downwards.

Relations of the Base

<i>In the Male.</i>		<i>In the Female</i>
Rectum, from which it is separated by	Recto - vesical pouch of peritoneum.	Recto-uterine pouch.
	Recto - vesical fascia	Cervix uteri and anterior vaginal wall
	Prostate.	
	Vasa deferentia and seminal vesicles	

The neck of the bladder is the part continuous with the urethra, and is embraced in the male by the prostate.

LIGAMENTS: There are two sets of ligaments of the bladder—true and false.

The **true ligaments** are two anterior and two lateral. These are formed of pelvic fascia. The urachus is usually described as the 5th or superior true ligament.

The **false ligaments**, five in number, are formed of peritoneum; there are two posterior (sacro-ventral

folds), two lateral, and a median, the latter covering the urachus. They have been described on p. 349.

• *Interior of the bladder*: Upon the inner surface of the base of the bladder, just behind the urethral orifice, is a triangular smooth surface or *trigone*, with the apex looking forwards. It is bounded laterally by two ridges passing to the openings of the ureters, the posterior angles being formed by those openings, placed $1\frac{1}{2}$ inches apart; at its apex there is an elevation, formed by the prostate, called the *uvula of bladder*, which is $1\frac{1}{2}$ inches from the ureters. Over the trigone the mucous membrane is smooth, but everywhere else elevated upon the irregular muscular wall and is rugose.

The Male Genital Organs

THE PROSTATE GLAND

The **prostate gland** surrounds the neck of the bladder and the first part of the urethra, which is placed nearer the anterior than the posterior surface of the gland. It resembles a horse-chestnut in shape, with the apex directed downwards. It measures about $1\frac{1}{2}$ inches across its base and $1\frac{1}{2}$ inches in depth, and 1 inch from before backwards, and is held in position by the anterior true ligaments of the bladder (pubo-prostatic ligaments).

The prostate is perforated by the common ejaculatory ducts (p. 379) which open into the floor of the prostatic urethra.

Relations:—

<i>Anterior or Pubic Surface.</i>	<i>Posterior Surface.</i>	<i>Base.</i>	<i>Apex.</i>
Symphysis pubis.	Rectum.	Surrounds neck	Rests on sub-
Anterior ligaments	Recto - vesical	of bladder.	pubic part of
of bladder.	fascia of	Seminal vesicles.	parietal pelvic
Retropubic fat.	Dénonvilliers.	Vasa deferentia.	fascia.
Dorsal vein of			
penis.	<i>Laterally.</i>		
	Levator ani.		

The prostate is surrounded by a sheath derived from the recto-vesical fascia and by the prostatic plexus of veins, and is supported by the levator ani.

BULBO-URETHRAL GLANDS

The **bulbo-urethral glands** are two small round bodies about the size of a pea, placed behind the membranous part of the urethra, between the perineal

membrane and the parietal pelvic fascia. Their ducts are about 1 inch long, and pass forwards, piercing the perineal membrane, to open into the spongy part of the urethra.

THE PENIS

The **penis** is divided into a root, body, and glans.

The *root* is attached to the perineal membrane, to the pubic rami by two strong processes, the *crura*, and to the symphysis pubis by the suspensory ligament.

The *glans* forms the extremity; at its summit is the opening of the urethra, the *external meatus*; passing from the lower margin of this is a fold of mucous membrane continuous with the prepuce and called the *frenulum*. At the base of the glans is a projecting edge or *corona*, and behind that a constriction, the neck of penis; sebaceous glands are found on both. The skin of the penis, attached to the neck of the glans, is doubled upon itself, forming the *prepuce* or *foreskin*.

The *body* is the part between the root and the glans, the upper surface being the *dorsum*.

The **corpora cavernosa**, placed dorsally, are two cylindrical columns connected together for the anterior 3ths, the *septum of penis* intervening, but separated behind to form the two *crura*, which are attached to the medial margins of the ischial and pubic rami; anteriorly the corpora cavernosa fit into the base of the glans. There is a groove on the upper surface for the dorsal vein of the penis and another groove on the lower surface for the corpus spongiosum; the corpora cavernosa are attached to the pubic symphysis by the suspensory ligament.

The **corpus spongiosum** commences at the perineal membrane by an enlargement, the *bulb*, and runs forward in the groove on the under surface of the corpora cavernosa, expanding over their extremities to form the *glans*. The *bulb* lies below the perineal membrane, and is embraced by the bulbocavernosus (bulbospongiosus) muscle. The urethra pierces the bulb on

its upper surface, and then runs forward in the middle of the corpus spongiosum.

THE MALE URETHRA

The urethra in the male extends from the neck of the bladder to the end of the penis, and has a length of from 6 to 8 inches. It is divided into three parts, according to the structures through which it passes.

(1) The **prostatic** part passes through the prostate gland from base to apex; this part is $1\frac{1}{2}$ inches long and spindle-shaped; in cross-section it is horseshoe-shaped, with the convexity forwards. On the posterior wall is a longitudinal ridge, the *urethral crest*, and on each side of this promontory is a depression, the *prostatic sinus*, into which the prostatic ducts open. Towards the anterior part of the urethral crest is a depression, the *prostatic utricle*, upon the elevated edges of which the ejaculatory ducts open.

(2) The **membranous** part extends from the apex of the prostate to the bulb, and is $\frac{3}{4}$ inch long; it is contained between the perineal membrane and the pelvic fascia, and is surrounded by the sphincter urethræ (p. 120).

(3) The **spongy** part is contained in the corpus spongiosum and occupies the rest of the canal, being from 4 to 6 inches long; the portion contained in the bulb is somewhat dilated, and the ducts of the bulbo-urethral glands open on the floor; the canal enlarges again just behind the *external meatus*, which enlargement is named the *fossa navicularis*. The lumen of this part of the urethra is transverse, except at the meatus (its narrowest part), where it is vertical, hence the spiral stream of urine.

The floor of the urethra is sprinkled with *lacunæ* (orifices of glands) which open forwards; one large one in the *fossa navicularis* is called the *lacuna magna*.

THE SCROTUM

The **scrotum** contains the testicles suspended by spermatic cords. The skin shows a median *raphe*,

and a fibrous septum divides the scrotal bag into two cavities; the left half is longer than the right, so the left testicle hangs down lower, the left spermatic cord being longer than its fellow.

Coverings of the testis in the scrotum :

1. Skin
2. Superficial fascia and dartos muscle
3. External spermatic fascia.
4. Cremaster muscle and fascia.
5. Internal spermatic fascia, continuous with the transversalis fascia.

} Common to both testes.

6. Tunica vaginalis testis, forms a closed sac. It invests the body and epididymis of the testicle except behind, where the duct and vessels are attached; It passes, laterally, a little between epididymis and body, forming the *sinus of the epididymis*.

THE SPERMATIC CORD

The **spermatic cord** consists of the vas deferens with artery to the vas, testicular artery and pampiniform plexus of veins (forming testicular vein above), sympathetic nerves, the artery to cremaster, the genital branch of the genito-femoral nerve, lymphatics, together with some areolar tissue; it extends from the deep inguinal ring to the testis, passing in its course along the inguinal canal, from which it emerges by the superficial inguinal ring, and thence in front of the pubis to the scrotum. The *vas deferens* is placed at the back of the cord, and may be recognized by its hard and cord-like feeling.

Boundaries of the inguinal canal (see p. 111).

THE TESTES (Fig. 72)

The **testes** are two glandular organs; each is suspended in the scrotum by the spermatic cord, which is attached to the posterior border. Each testis consists of two parts: the *body*, which is anterior, and the *epididymis*, placed posteriorly; to the lower end of this latter the duct or vas deferens is attached.

' Coverings of the testis :

1. *Serous* or *tunica vaginalis* is derived from the peritoneum. Strictly speaking, the *tunica vaginalis* does not cover the testis itself, being attached all around to the *tunica albuginea*; i.e. there is only a parietal, and not a true visceral, layer.

2. *Fibrous* or *tunica albuginea* covers the body of

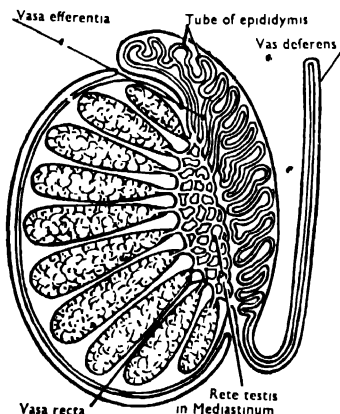


FIG. 72.—DIAGRAMMATIC SECTION OF TESTIS TO SHOW THE COURSE OF SPERMATOZOA FROM THE TUBULES OF THE TESTIS TO THE VAS DEFERENS.

Namely: Seminiferous tubules—vasa recta—rete testis—vasa efferentia—tubule of epididymis—vas deferens.

the testicle, sending in posteriorly a vertical septum the *mediastinum testis*; this latter gives off secondary processes or *septa*, which serve to separate the lobules of the testicle.

The *epididymis* is a long narrow body, consisting of three parts—viz. a superior portion projecting forwards on the upper end of the body, the *head*; a lower, the *tail*, with which the *vas deferens* is continuous; and between these two, the *body*. The epididymis consists of a duct 20 feet long, exceedingly convoluted, and bound together by areolar tissue; it

receives the efferent ductules at the upper part of the testicle.

The body of the testicle consists of numerous lobules of pyramidal shape, which are formed by septa, mediastinum, and tunica albuginea, the base of the lobule being directed to the circumference of the testis, and the apex towards the mediastinum. Each lobule contains one or more convoluted *seminiferous tubules* held together by areolar tissue. Each tubule commences near the base, in a blind extremity, becoming straighter near the apex; as they enter the mediastinum, they coalesce together to form twenty or thirty *straight tubules*.

The *straight tubules* pierce the mediastinum and interlace to form the *rete testis*.

Twelve to twenty tubules pass from the upper part of the rete as the *efferent tubules*.

The *efferent tubules* perforate tunica albuginea, being at first straight, then convoluted, and as the *lobules of the epididymis* form the head of the *epididymis*.

The *lobules of the epididymis* open into the excretory duct at intervals (when unravelled) of about 3 inches.

The **vas deferens** commences at the tail of the epididymis as the continuation of the duct of the epididymis, and ascends in the spermatic cord through the inguinal canal and deep inguinal ring. Here it crosses the inferior epigastric artery, and, lying outside the peritoneum, passes medially to reach the medial side of the external iliac artery; then, lying on the lateral pelvic wall, it crosses the obliterated umbilical artery (lateral umbilical ligament), obturator nerve and vessels, vesical vessels and ureter. At the base of the bladder it runs medial to the seminal vesicles and loses contact with peritoneum. It dilates into the *ampulla*, being separated from the rectum by the recto-vesical fascia; narrowing again at the base of the prostate, it unites with the duct of the seminal vesicle of the same side, and forms the *common ejaculatory duct*, which passes forwards through the prostate and opens on the edge of the orifice of the prostatic utricle into the prostatic urethra.

THE SEMINAL VESICLES

' The **seminal vesicles** are two sacculated pouches, placed between the base of the bladder in front and the rectum behind. They are pyramidal in shape, the upper end being the wider; anteriorly they converge to enter the prostate near the middle line. The corresponding vas deferens lies on the medial side.

The Female Genital Organs

The external genital organs in the female are: the mons pubis, the labia majora, the labia minora, the clitoris, the external orifice of the urethra, and the orifice of the vagina. The term *vulva* includes the whole of these.

The **mons pubis** is the eminence in front of the pubis, covered with hair.

The **labia majora** are two prominent folds extending from the mons to the perineum. Externally they are covered with hair and skin, internally with mucous membrane; the labia are joined together anteriorly and posteriorly, forming commissures. A small transverse fold of mucous membrane is found in the posterior commissure called the *frenulum labiorum*; the space between this and the posterior commissure is known as the *vestibular fossa*.

The **labia minora** are two folds of mucous membrane, extending for $1\frac{1}{2}$ inches downwards and laterally from the clitoris, finally losing themselves below in the labia majora. They surround the clitoris, the upper folds forming the prepuce of the clitoris, the lower ones, attached to the glans, being the *frenulum of the clitoris*.

The **clitoris**, corresponding somewhat in structure to the penis, is placed just below the anterior commissure. It consists of two corpora cavernosa attached to the pubic rami by two crura; the free extremity or glans is formed by the corpus spongiosum. Between the labia minora, and bounded anteriorly by the clitoris, is the *vestibule*, at the back part of which the external urethral orifice opens, being about 1 inch below the clitoris.

The bulb of the vestibule : A mass of erectile tissue lying deep to the labia minora, and resting on the inferior surface of the perineal membrane.

Below the meatus is the orifice of the vagina, closed more or less in the virgin by the *hymen*, which is a duplicature of mucous membrane, generally semilunar in shape. After its rupture small elevations, hymeneal caruncles, remain.

The **greater vestibular glands**, analogous to bulbourethral glands in the male, are situated on each side near the entrance of the vagina, and their ducts open on the labia minora, external to the hymen.

The **urethra** in the female is only $1\frac{1}{2}$ inches long, and is adherent to the anterior wall of the vagina. The external orifice of the urethra opens between the labia minora, about an inch below and behind the clitoris.

The **vagina** is a dilatable canal, the axis of which is naturally transverse, extending from the vulva to the uterus; the anterior wall is about $3\frac{1}{2}$ inches and the posterior wall $4\frac{1}{2}$ inches long. The upper end widens to receive the neck of the uterus, which it meets at an angle anteriorly of about 90 degrees.

The relations are:

<i>Anteriorly.</i>	<i>Posteriorly.</i>	<i>Laterally.</i>
Base of bladder.	Perineum.	Broad ligament
Urethra.	Rectum and anal canal	and ureter
	Recto-vaginal pouch (upper inch)	Levator ani
		Sphincter vaginæ (pubo-vaginalis).

There is a median ridge or raphé on the mucous surface of both the anterior and posterior walls. The walls likewise present many transverse ridges or *rugæ*. The lower end of the vagina is embraced by the sphincter vaginæ (p 119).

THE UTERUS (Fig. 73)

The **uterus** or womb is a pear-shaped body, flattened from before backwards, placed in the pelvis between the bladder and rectum. The nulliparous adult

uterus is about $2\frac{1}{2}$ inches long, its long axis being directed forwards and upwards in the line of the axis of the pelvis. Peritoneum covers the back of the uterus and extends down on to the vagina; anteriorly only the upper $\frac{2}{3}$ of the uterus is covered. The peritoneum is reflected from the uterus to the sides of the pelvis, forming the *broad ligaments*. The uterus is divided, for the purpose of description, into three parts:—

(1) The *fundus* is the broad upper end of the body, convex in both directions and covered by peritoneum.

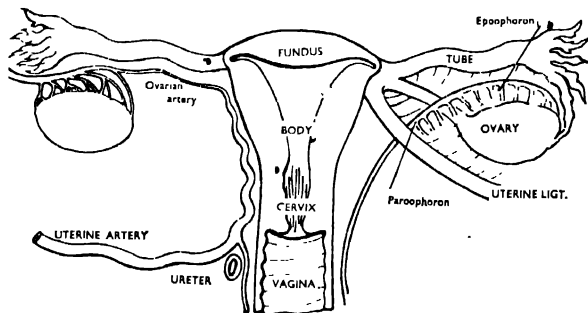


FIG. 73.—DIAGRAM OF UTERUS AND OF THE CONTENTS OF THE BROAD LIGAMENT.

Note the ureter passing under the uterine artery close to the cervix

(2) The *body* extends from the fundus to the neck, narrowing as it approaches the latter; at the junction of the fundus and body is an angle to which the *uterine tube* is attached; a little anteriorly to this the *round ligament* of the uterus is connected; below and behind this the *ovarian ligament* is attached.

(3) The *neck* or *cervix uteri* is surrounded below by the vagina, into which it projects, forming a vaginal part, which presents a rounded opening, the *os uteri*, bounded by two thick lips, anterior and posterior, of which the anterior is the thicker and the

posterior the longer. The recesses in front of the anterior and behind the posterior lips are the *anterior* and *posterior vaginal fornices*, of which the posterior is much the deeper, and is in direct contact with peritoneum (recto-vaginal pouch).

The *cavity* of the uterus, flattened from before backwards, is triangular in shape, the superior angles leading to the uterine tubes. Where the body joins the neck there is a constriction, the *isthmus uteri*.

The **ligaments** are two anterior or utero-vesical, two posterior or recto-uterine, and two lateral or broad ligaments, all formed of peritoneum.

Recto-uterine "ligaments" are folds of peritoneum bounding the recto-uterine pouch (Douglas). Beneath these folds are thickenings of pelvic fascia, forming the *utero-sacral ligaments*.

The *broad ligaments* are formed of a double layer of peritoneum passing from the lateral margins of the uterus to the sides of the pelvis. Between the two layers of this ligament on each side are the uterine tube, the round ligament of the uterus, and foetal relics, the ep-oöphoron and par-oöphoron, the ovary and its ligament, uterine and ovarian vessels, nerve and lymphatics. Below broad ligaments lie strong thickenings of pelvic fascia, forming the *lateral ligaments* of the cervix.

The *round ligament* is a cord placed between the layers of the broad ligament, extending from the superior angle of the uterus to the deep inguinal ring, thence it passes into the inguinal canal to lose itself in the labium majus. In the foetus it is covered for some part of the way in the inguinal canal by peritoneum, the *processus vaginalis*; this process may persist.

THE APPENDAGES OF THE UTERUS

The **uterine tubes** (Fallopian tubes) are two in number, placed in the upper margins of the broad ligaments, and about 4 inches in length. The cavity of each tube commences by a narrow orifice called the *pelvic opening*, which lies at the bottom of

trumpet-shaped expansion, the *infundibulum*, the margin of which bears a number of irregular processes, the *fimbriæ*.

Where the tube joins the uterus it is narrow and termed the *isthmus*; between this and the abdominal opening is a dilatation extending rather more than half the length of the tube, termed the *ampulla*.

The fimbriated extremity is closely applied to the tubal end and free border of the ovary, and is attached by the *ovarian fimbria* to the tubal end of the ovary.

The **ovaries** are two in number, and correspond to the testes in the male; they are of a flattened ovoid form, vertically placed on the posterior surface of the broad ligament. The anterior border of the ovary is attached to the broad ligament by the *mesovarium* containing the ovarian vessels, the posterior border is free. The upper pole is embraced by the uterine tube; the lower pole is attached to the upper angle of the uterus by the *round ligament of the ovary*. The medial surface is free; the lateral lies in the *ovarian fossa* between the internal and external iliac vessels and just in front of the ureter, on the obturator foramen.

The **ep-ööphoron** lies between the uterine tube and ovary, and the **par-ööphoron** between the ovary and the uterus; they are remains of the Wolffian body.

THE BREAST

The breast (*mammary gland*) is rudimentary in male and in female child. Gland enlarges in female at puberty. During lactation enlarges further. Developed gland consists of 15 to 20 lobules separated by incomplete fibrous septa that radiate out from the nipple. Each lobule opens by separate duct on the nipple, the duct being dilated into *lactiferous sinus* just below surface of nipple. Nipple surrounded by pink *areola* which usually becomes permanently pigmented early in first pregnancy (degree of brownness depends on colouring of individual). Contour of breast results from subcutaneous fat, absent under areola and nipple.

Gland has no capsule. Lies in subcutaneous tissue over pectoralis major and serratus anterior, often sends *axillary tail* upwards over latter muscle. Overlies 2nd to 6th ribs, from side of sternum to anterior axillary line.

Blood supply: Lateral thoracic, perforating branches of intercostals and internal thoracic (mammary), especially through 2nd and 3rd spaces.

Lymph drainage: Highly important (see p. 199).

The Ductless Glands

THE SPLEEN

Not a ductless gland, but included here for convenience. Situated in the left hypochondrium and epigastrium, is of an oblong, flattened form, the lateral surface being convex; on the medial surface is a vertical ridge dividing it into two parts, the posterior of which is applied to the lateral part of the anterior surface of the left kidney, whilst the anterior receives the tail of the pancreas, and lies against the fundus of the stomach. Near this ridge is a fissure, the *hilum*, where the vessels enter. The anterior border is notched, and the inferior or basal surface is triangular, and rests on the phrenico-colic ligament and the left flexure of the colon. It is covered, except at the hilum, by peritoneum, which here passes forwards and medially in a double line enclosing the vessels, as the *gastro-splenic* ligament, to the fundus of the stomach; behind the hilum two layers pass on to the left kidney as the *hepato-renal* ligament.

Relations—Lateral surface : Diaphragm, which separates it from the 9th, 10th, and 11th left ribs, lung, and pleura

Medial surface—In front of the hilum : Fundus of stomach. *Behind the hilum* : Left kidney. *Below the hilum* : Tail of pancreas.

Inferior surface : Phrenico-colic ligament and left flexure of colon.

Artery and vein : Splenic.

Nerves : Branches from coeliac plexus.

THE THYROID GLAND

The **thyroid gland** is situated on the upper part of the trachea, and consists of two lateral lobes united at lower part by isthmus, which lies over 2nd, 3rd, and 4th rings of trachea and is covered by skin, superficial and cervical fasciæ, and anterior jugular veins.

Each lobe is pear-shaped, with smaller end upwards.

Enveloped in pre-tracheal fascia, which strips freely from gland except at poles (where vessels perforate it) and between isthmus and trachea. Hence moves up and down with larynx in swallowing.

Dimensions : Vertical, $1\frac{1}{2}$ inches; transverse, $\frac{3}{4}$ inch; thick, $\frac{1}{2}$ inch.

Relations of lateral lobes :

Antero-lateral (convex) surface : Cervical fascia, sterno-mastoid, sterno-thyroid, sterno-hyoid, and omo-hyoid muscles.

Postero-medial (concave) surface : Upper six rings of trachea, cricoid and thyroid (below oblique line), crico-thyroid and inferior constrictor muscles, inferior thyroid artery, recurrent laryngeal and external laryngeal nerves, œsophagus (on left side).

Postero-lateral (convex) surface : Sheath of carotid vessels.

Vessels : Arteries, superior and inferior thyroid, thyroidea ima; veins, superior, middle, and inferior thyroid

THE PARATHYROIDS

These are two small bodies on each side, situated at the back of the lateral lobes of the thyroid gland, *within its capsule*. The upper is about the level of the cricoid cartilage, the lower near the lower pole of the thyroid. They are supplied by the posterior branches of the superior and inferior thyroid arteries, which anastomose on the back of the thyroid gland.

Upper (parathyroid IV) is developed from 4th pharyngeal pouch, lower (parathyroid III) from 3rd pouch is pulled caudally during descent of thymus from 3rd pouch.

THE THYMUS GLAND

The **thymus gland** attains its full size at about two years, after which it gradually shrinks away. It is situated partly in the anterior mediastinum, and partly in the neck, reaching from level of 4th costal cartilage upwards on the trachea as high as the lower border of thyroid gland. It consists of two lateral lobes with occasionally a middle connecting one.

Relations of each lobe in early life : •

Anterior: Sternum as low as 4th costal cartilages, origins of sterno-hyoid and sterno-thyroid muscles.

Posterior: Trachea, pericardium, and great thoracic vessels.

Base : Pericardium

Laterally : Pleura, sheath of carotid.

Medially : Opposite lobe and side of trachea.

THE SUPRARENAL GLANDS

are asymmetrical. Right is pyramidal and embraces upper pole of right kidney, left crescentic and embraces medial border of left kidney above the hilum. The right usually has no peritoneum in front, but the left is covered in front by peritoneum, except where the pancreas crosses it. (Fig 70).

Relations :

Anterior—Right : Liver, inferior vena cava. *Left :* Stomach and lesser sac of peritoneum, pancreas.

Posterior : Diaphragm.

Inferior : Top of kidney.

Arteries : Relatively large, three to each gland—namely, the superior suprarenal from the inferior phrenic, the middle suprarenal from the aorta, the inferior suprarenal from the renal.

Veins, one only on each side : Right into the inferior vena cava; the left into the left renal.

Nerves : Very numerous, from the splanchnic nerves through the coeliac and renal plexuses.

PITUITARY GLAND

See hypophysis cerebri (p. 222). Occupies sella turcica of sphenoid. Fossa roofed in by dura mater (*diaphragma sellæ*), pierced by stalk of pituitary (*infundibulum*), which depends from tuber cinereum. Has optic chiasma above, cavernous sinus to each side and sphenoidal sinus below. Anterior larger and more vascular than posterior lobe.

INDEX

- Action of paradox, 44
 Aditus ad antrum, 302
 Alar synovial folds of the knee,
 35
 Alveus, 233
 Ampulla of rectum, 337*
 of vas, 379
 Ampullæ of the semicircular
 canals, 305
 Anastomosis, cruciate, 172
 trochanteric, 169
 Angle, carrying, 22
 Ansa cervicalis, hypoglossi,
 259, 262
 Antrum, mastoid, 305
 tympanic, 305
 Aorta, 131
 abdominal, 159
 arch of, 132
 ascending, 131
 thoracic, 133
 Aponeurosis, bicipital, 74
 of external oblique, 108
 of internal oblique, 110
 palmar, 84
 plantar, 103
 of the soft palate, 323
 of the transversus ab-
 dominis muscle, 110
 Appendix, vermiform, 336
 Aqueduct of cochlea, 306
 of midbrain, 220
 of the vestibule, 305
 Arch, coraco-acromial, 19
 palmar, deep, 157
 superficial, 159
 plantar, 178
 Arches of foot, 43
 Artery, acromio-thoracic, 153
 of Adamkiewicz, 149
 antero-medial ganglionic,
 145
 arcuate, 175
 auditory, internal, 145
 auricular, anterior, 140
 Artery, deep, 141
 posterior, 139
 axillary, 152
 basilar, 145
 brachial, 154
 brachio-cephalic, 132
 bronchial, 133
 buccal, 142
 of bulb, 167
 calcanean, 177
 carotico-tympanic, 143
 carotid, common left, 135
 right, 134
 external, 136
 internal, 142
 carpal, anterior, 156
 posterior, 156
 ulnar, anterior, 158
 posterior, 158
 central, retina, 144, 316
 cerebellar, anterior in-
 ferior, 145
 posterior inferior, 149
 superior, 145
 cerebral, anterior, 145
 middle, 145
 posterior, 146
 cervical, ascending, 150
 deep, 152
 superficial, 151
 transverse, 151
 choroid, 145
 ciliary, anterior, 144
 posterior, 144
 circumflex fibular, 174
 humeral, anterior,
 154
 posterior, 154
 iliac, deep, 169
 superficial, 171
 lateral, 171
 medial, 172
 scapular, 154
 clavicular, 153
 of clitoris, 167

Artery, coccygeal, 169
 coeliac, 160
 colic, left, 163
 middle, 162
 right, 162
 communicating (cerebri)
 anterior, 145
 posterior, 145
 companion artery of
 sciatic nerve, 169
 coronary, left, 128
 right, 128
 of corpus cavernosum,
 167
 cortical, 145
 costo-cervical trunk, 152
 cremaster, 168
 crico-thyroid, 137
 cystic, 161
 deltoid, 153
 dental, anterior, 142
 inferior, 142
 posterior superior, 142
 digital, palmar, 159
 (pedis), 175
 dorsal carpal arch, 159
 dorsalis linguae, 137
 nasi, 144
 pedis, 175
 penis, 167
 pollicis, 157
 epigastric, inferior, 168
 superficial, 171
 superior, 152
 ethmoidal, anterior, 144
 posterior, 144
 facial, 137
 femoral, 170
 fibular, circumflex, 174
 gastric, left, 160
 right, 160
 gastro-duodenal, 160
 epiploic, left, 160
 right, 160
 genicular, descending, 173
 inferior, 174
 middle, 174
 superior, 174
 gluteal, inferior, 169
 superior, 170
 hallucis, magna, 176
 hepatic, 160, 342

Artery, hypophyseal, 143
 ileal, 162
 ileo-colic, 162
 iliac, circumflex, deep, 169
 common, 164
 external, 168
 internal, 165
 ilio-lumbar, 167
 inquisive, 141
 infra-hyoid, 136
 -orbital, 142
 -spinous, 150
 innominate, 132
 intercostal, anterior, 151
 collateral, 134
 posterior, 134
 superior, 152
 supreme, 152
 interosseous, anterior, 158
 common, 158
 posterior, 158
 recurrent, 158
 jejunal, 162
 labial, inferior, 138
 superior, 138
 labyrinthine, 145
 lacrimal, 144
 laryngeal, inferior, 150, 158
 superior, 136
 lingual, 130
 lumbar, 164
 malleolar, 175
 mammary, internal, 151
 marginal, 163
 masseteric, 142
 mastoid, 139
 maxillary, 140
 mediastinal, 133
 medullary, 149
 meningeal, accessory, 141
 anterior, 143
 middle, 141
 posterior, 149
 mental, 141
 mesenteric, inferior, 163
 superior, 161
 metacarpal, dorsal, 156
 palmar, 157
 metatarsal, dorsal, 176
 plantar, 177
 musculo-pharyngeal, 152
 mylo-hyoid, 141

Artery, nasal, 144
 lateral, 138
 of septum, 142
 nutrient, of femur, 172
 of humerus, 155
 of tibia, 177
 obturator, 166
 abnormal, 169
 occipital, 138
 oesophageal, 133, 150
 ophthalmic, 143
 ovarian, 163
 palatine, ascending, 137
 greater, 142
 lesser, 142
 palmar arch, deep, 157
 superficial, 159
 metacarpal, 157
 superficial, 156
 palpebral, 144
 pancreatic, 161, 344
 pancreatico-duodenal, 161
 penis, deep, 167
 perforating, femoral, 172
 foot, 178
 hand, superior, 157
 of internal mammary, 151
 pericardiaco-phrenic, 151
 pericardial, 133
 perineal, transverse, 167
 peroneal, 176
 petrosal, superior, 141
 pharyngeal, ascending, 139
 phrenic, 160
 plantar arch, 178
 lateral, 178
 medial, 177
 metatarsal, 178
 pontine, 146
 popliteal, 173
 postero-lateral ganglionic, 146
 -medial ganglionic, 136
 princeps pollicis, 157
 profunda brachii, 155
 femoris, 171
 of tongue, 137
 pterygoid, 142
 pterygo-palatine, 142

Artery, pubic, 166, 169
 pudendal, deep external, 171
 internal, 166
 superficial external, 171
 pulmonary, 130
 left, 131
 right, 130
 radial, 155
 recurrent, 156
 radialis indicis, 157
 rectal, inferior, 167
 middle, 165
 superior, 163
 recurrent, interosseous, posterior, 158
 radial, 156
 tibial, 174
 ulnar, anterior, 158
 posterior, 158
 renal, 162
 retinae centralis, 144, 316
 sacral, lateral, 168
 median, 164
 scrotal, 167
 septal posterior, 142
 spheno-palatine, 142
 spinal, anterior, 149
 posterior, 149
 splenic, 161
 sterno-mastoid, 136, 139
 striate, 145
 stylo-mastoid, 139
 subclavian, left, 146
 right, 146
 sublingual, 137
 submental, 138
 subscapular, 154
 supra-hyoid, 137
 -orbital, 144
 -renal, 389
 inferior, 162
 middle, 161
 superior, 160
 supra-scapular, 150
 -trochlear, 155
 tarsal, 175
 temporal, anterior, 140
 deep, 142
 middle, 140
 posterior, 140

-tery, temporal superficial, 140
 testicular, 162
 thalamo-striate, 146
 thoracic, lateral, 153
 superior, 153
 thyro-cervical trunk, 149
 thyroid, inferior, 149
 superior, 136
 thyroidea ima, 133
 tibial, anterior, 174
 posterior, 176
 tonsillar, 138, 324
 tracheal, 150
 transverse facial, 140
 tympenic, 141
 ulnar, 157
 collateral, 155
 recurrent, 158
 uterine, 165
 vaginal, 165
 vas deferens, 165
 vertebral, 148
 vesical, inferior, 165
 superior, 165
 zygomatic, 140
 Articulation, acromio-clavicular, 17
 ankle, 37
 atlanto-axial, 8
 atlanto-occipital, 7
 of bones of the tympanum, 303
 of carpal bones, 24
 carpo-metacarpal, 24
 chondro-sternal, 11
 costo-chondral, 11
 -vertebral, 10
 crico-arytenoid, 355
 -thyroid, 355
 elbow, 20
 hip, 28
 knee, 31
 lumbo-sacral, 9
 mandibular, 13
 of the metacarpal bones, 24
 metacarpo-phalangeal, 25
 metatarsal, 42
 metatarso-phalangeal, 43
 phalangeal, of fingers, 25
 of toes, 43

Articulation, radio ulnar,
 inferior, 22 superior, 22
 sacro-iliac, 25
 shoulder, 18
 sternal, 12
 sterno-clavicular, 15
 -costal, 11
 subtaloid, 40
 symphysis pubis, 28
 talo-calcaneal, 40
 -calcaneo - navicular, 41
 tarsal, 40
 tarso-metatarsal, 41
 thumb, 25
 tibio-fibular, 36
 of vertebræ, 5
 wrist, 24
 Atrium, left, 127
 right, 123
 Auricle of the ear, 300
 of the heart, left, 127
 right, 123
 Autonomic nervous system, 284
 Axilla, walls of, 73
 Band, moderator, 126
 septo-marginal, 126
 Bladder, 371
 ligaments of, 372
 lymphatics, 201
 Body, geniculate, lateral, 221
 medial, 222
 mamillary, 222
 pineal, 222
 Brain, 209
 membranes of, 237
 Breast, 385
 lymph drainage, 199
 Bronchus, left, 361
 right, 361
 segmental, 365
 Bulb, artery of, 167
 olfactory, 229
 of the urethra, 376
 of the vestibule, 382
 Bundle, conducting, 129
 Bursa, iliacus, 88
 of knee, 35
 subacromial, 20

- Cæcum, 336
 Calamus scriptorius, 214
 Calyces of the kidney, 370
 Canal, adductor, 91
 anal, 338
 of cochlea, 306
 hyaloid, 317
 inguinal, 111
 pudendal, 118
 semicircular, 305
 of spinal cord, 200
 spiral of modiolus, 306
 of the tensor tympani, 302
 Canaliculi, lacrimal, 310
 Capsule of lens, 317
 Cartilage, arytenoid, 356
 corniculate, 356
 cricoid, 355
 cuneiform, 356
 of the ear, 300
 semilunar (menisci), 35
 thyroid, 355
 Cartilages of the knee, 35
 of the larynx, 354
 of the nose, 351
 of trachea, 360
 Cartilago triticea, 357
 Caruncle, lacrimal, 300
 Caruncles, hymeneal, 382
 Cauda equina, 205
 Caval opening diaphragm, 116
 Cavum trigeminale, 242
 Cerebellum, form of, 217
 lobes of, 217
 peduncles, 218
 structure of, 217
 Cerebrum, division into lobes, 225
 form of, 224
 interior, 230
 synopsis of tracts, 236
 • Cervix uteri, 383
 Chamber of the eye, anterior, 317
 posterior, 318
 Chiasma of the optic nerves, 222
 Chordæ tendineæ, 126
 Ciliary body, 314
 Circulus vasculosus, 4
 Cisterna, cerebello-medullary, 239
 chyli, 195
 interpeduncular, 219
 Claustum, 235
 Clitoris, 381, artery, 167
 Cochlea, 306
 canal of, 306
 duct of, 307, 308
 nerves of, 308
 Colliculus, 220
 facial, 215
 Colon, 336
 Columns, anal, 338
 of the fornix, 234
 of the spinal cord, 207
 Commissure, anterior, 223
 grey, of the cord, 206
 hippocampal, 234
 posterior, 221
 white, of the cord, 207
 Conjoined tendon, 110
 Conjunctiva, 310
 Connexus, intertendinous, 80
 interthalamicus, 221
 Constrictors, pharynx, 328
 Conus elasticus, 357
 medullaris, 205
 Cord, oblique, 23
 spermatic, 377
 spinal, 204
 Cords, vocal, 357
 Cornea, 313
 Corpora cavernosa, 375
 mamillaria, 222
 quadrigemina, 220
 striata, 235
 Corpus callosum, 229
 spongiosum, 375
 Crest, ampullary, 307
 vestibular, 305
 Crista terminalis, 124
 Crura of the diaphragm, 115
 of the penis, 375
 Cuneus, 228
 Cupola, 306
 Cusp, aortic, 127
 pulmonary, 126
 Decussation of the pyramids, 214
 Dermatomes, 284
 Diaphragm, 115
 Diencephalon, 220

- Disc, acromio-clavicular, 17
 interpubic, 28
 intervertebral, 4
 optic, 317
 radio-ulnar, 23
 sterno-clavicular, 16
 temporo-mandibular, 13
 Duct, bile, 342
 of cochlea, 308
 common hepatic, 342
 cystic, 342
 ejaculatory, 579
 endolymphatic, 307
 lymphatic, 195
 naso-lacrimal, 311
 pancreatic, 313
 parotid, 325
 semicircular, 307
 sublingual, 326
 submandibular, 326
 thoracic, 195
 Ductus arteriosus, 130
 reunens, 307
 venosus, 340
 Duodenum, 333
 Dura mater, 237
 of the cord, 208
 Ear, external, 300
 internal, 305
 middle, 301
 Eminentia collateralis, 225
 Endocardium, 128
 Endolymph, 307
 Epididymis, 378
 Epiglottis, 356
 Ep-oöphoron, 385
 Eversion of foot, 42
 Eye-ball, 311
 brows, 309
 Eye-lids, 309
 muscles of, 45
 structure, 309
 Falx cerebelli, 238
 cerebri, 237
 Fascia, bicipital, 74
 bulbi, 311
 cervical, 53
 clavipectoral, 69
 cremasteric, 377
 cribriform, 89
 of the forearm, 75
 ilac, 88
 lata, 89
 of the leg, 97
 lumbar, 62
 palpebral, 310
 parotid, 325
 pelvic, 117
 pharyngo-basilar, 327
 pretracheal, 55
 prevertebral, 54
 psoas, 88
 spermatic, external, 377
 internal, 377
 transversalis, 110
 Fasciculus cuneatus, 206, 212
 gracilis, 206, 210
 Fenestra, cochleæ, 301
 vestibuli, 301
 Fibres, arcuate, 213
 of the cerebellum, 217
 of the cerebrum, 236
 post-ganglionic, 286
 pre-ganglionic, 286
 projection, 236
 Filum terminale, 205
 Fissure for inferior vena cava,
 310
 for ligamentum teres, 340
 venosum, 340
 longitudinal, 223
 transverse, 224
 Fissures of the cerebellum, 217
 of the cerebrum, 223
 choroid, 224
 of the cord, 205
 of the liver, 340
 of the medulla, 209
 Flexure, duodeno-jejunal, 334
 hepatic, 336
 splenic, 337
 Flocculus, 217
 Folds, glosso-epiglottic, 356
 pharyngo-epiglottic, 356
 recto-uterine, 345
 umbilical, 349
 Follicles, lingual, 321
 Foramen caecum, 320
 for inferior vena cava, 116
 interventricular, 234
 ovale, 125
 Forceps, major, 230

- Forceps, minor, 230
 Foreskin, 375
 Formatio reticularis, 207
 Fornix, 233
 Fossa, cubital, 79
 for gall bladder, 341
 ischio-rectal, 118
 navicularis, 376
 ovalis, 125
 piriform, 328
 terminalis of the urethra, 376
 Fosse of abdominal wall, 346
 Fovea centralis, 316
 Fovea of fourth ventricle, 214
 Frenulum of prepuce, 375
 of tongue, 320
 Gall bladder, 341
 Ganglia, autonomic system, 288
 basal, 235
 cervical, inferior, 295
 middle, 295
 superior, 93
 collateral, 289
 cranial autonomic, 289
 of glosso-pharyngeal, 254
 lateral, 288
 lumbar, 296
 sacral, 296
 of spinal nerves, 205
 terminal, 289
 thoracic, 296
 Ganglion, ciliary, 244
 impar, 297
 otic, 250
 phrenic, 298
 pterygo-palatine, 245
 spheno-palatine, 245
 spiral, 309
 stellate, 296
 submandibular, 249
 trigeminal, 242
 of the vagus, 255
 vestibular, 308
 Genu of corpus callosum, 231
 Gland, bulbo-urethral, 374
 labial, 326
 lacrimal, 310
 lingual, 321
 mammary, 385
 of, 199
 molar, 326
 parotid, 325
 pineal, 222
 pituitary, 396
 prostate, 374
 lymphatics, 201
 sublingual, 326
 submandibular, 326
 suprarenal, 389
 tarsal, 320
 thymus, 389
 thyroid, 388
 urethral, 376
 vestibular, 382
 Glands, lymphatic, axillary, 198
 bronchial, 202
 cervical, 196
 celiac, 201
 facial, deep, 196
 femoral, 203
 iliac, 201
 inguinal, 203
 intercostal, 202
 jugulo-digastric, 197
 jugulo-omohyoid, 197
 mastoid, 196
 mediastinal, 202
 popliteal, 203
 sternal, 202
 of stomach, 200
 submandibular, 196
 submental, 196
 suboccipital, 196
 Glans of the clitoris, 381
 of the penis, 375
 Globus pallidus, 235
 Glottis, 357
 Grey matter of the cord, 206
 Gyrus cinguli, 226
 dentate, 230
 frontal, 226
 hippocampal, 229
 occipital, 227
 occipito-temporal, 228
 precentral, 226
 rectus, 226
 temporal, 228
 Hamulus of spiral lamina, 308

Hand, fascial spaces, 84
 Heart, 121
 Helicotrema, 306
 Hilton's Law, 4
 Hippocampus, 232
 Humour, aqueous, 317
 Hymen, 382
 Hypophysis cerebri, 390

Ileum, 335

Incus, 303

Indusium griseum, 229

Infundibulum of the brain, 222
 of frontal sinus, 353
 of right ventricle, 125
 of uterine tube, 385

Insertion of muscles, 44

Insula, 229

Intestine, large, 335

 small, 333

Inversion of foot, 41

Iris, 314

Isthmus, oro-pharyngeal, 323

Jejunum, 335

Joints (see Articulations)

 blood supply, 3

 , cartilaginous, 1

 development, 3

 nerve supply, 4

 synovial, 1

Kidney, 368

Labia majora, 381

 minora, 381

Labrum acetabulare, 28

 glenoidale, 19

Labyrinth, bony, 305

 membranous, 307

Lacunæ laterales, 188

 of the urethra, 376

Lacus lacrimalis, 309

Lamina, basilar, 308

 chorio-capillary, 314

 cribrosa scleræ, 312

 fusca, 312

 spiral, of cochlea, 306

 suprachoroid, 313

 terminalis, 223

Larynx, 354

 cartilages, 354

Larynx, inlet of, 357

 anterior, 357

 ligaments, 356

 lymphatics, 197

 muscles, 358

 nerves, 358

 sacculæ of, 358

 vessels, 358

Law, Hilton's, 4

Lens, 317

Ligament, acromio-clavicular,

 17

 anterior, of the knee, 35

 of the dens, 9

 ankle-joint, 39

 annular (orbicular) of

 radius, 22

 apical, 9

 arcuate, 33

 of diaphragm, 115

 atlanto-axial, 8

 accessory, 9

 transverse, 8

 -occipital, 7

 bifurcate, 41

 broad, 349, 384

 calcaneo-cuboid, 42

 -fibular, 39

 -navicular (spring),

 41

 capsular, of the elbow, 21

 of the hip, 29

 of the knee, 33

 of the mandible, 13

 of the shoulder, 19

 conoid, 17

 coraco-acromial, 19

 -clavicular, 17

 -humeral, 19

 coronary, of liver, 340,

 349

 costo-clavicular, 16

 -transverse, lateral,

 11

 superior, 11

 crico-thyroid, 357

 cruciate, 9

 of knee, 34

 cruciform, 9

 deltoid, 39

 elbow, collateral, 21

 falciform, 340, 349

Ligament, gastro-splenic, 350
 gleno-humeral, 19
 of head of femur, 29
 hyo-epiglottic, 356
 ilio-femoral, 29
 -lumbar, 27
 infundibulo-pelvic, 349
 inguinal, 108
 interclavicular, 15
 interfoveolar, 111
 interosseous, of carpus, 24
 of cuneiform bones, 42
 of metacarpal bones, 25
 of metatarsal bones, 42
 of talus and calcaneum, 40
 of the tibia and fibula, 37
 interspinous, 7
 intertransverse, 7
 intra-articular (rib), 11
 ischio-femoral, 29
 lacunar, 108
 lino-renal, 350
 longitudinal, of vertebrae, 5
 of malleus, 304
 menisco-femoral, 35
 metacarpal, 24
 metacarpo-phalangeal, 25
 metatarsal, 42
 of neck of rib, 11
 oblique cord, 23
 posterior, of knee, 34
 of the patella, 33
 pectinate, of ribs, 313
 of the phalanges, 25
 phrenico-colic, 337
 plantar, 42
 pybo-femoral, 29
 -prostatic, 372
 pulmonary, 362
 quadrate, 23
 radiate, 11
 radio-carpal, 24
 -ulnar, 22
 round, of the liver, 340
 of the uterus, 364
 sacro-iliac, anterior, 26

Ligament, sacro-iliac, oblique, 26
 posterior, 26
 -spinous, 27
 -tuberosus, 27
 spheno-mandibular, 13
 of spleen, 350
 spring, 41
 of stapes, 304
 sterno-clavicular, 15
 -costal, 12
 stylo-mandibular, 14
 supraspinous, 7
 suspensory, of lens, 317
 of penis, 375
 talo-calcaneal, 39
 -fibular, 39
 thyro-epiglottic, 356
 -hyoid, 357
 tibio-fibular, 37
 transverse, of the atlas, 8
 of the hip, 28
 of the knee, 35
 trapezoid, 17
 triangular, liver, 340, 349
 of tubercle of rib, 11
 umbilical, 349
 vocal, 356
 wrist, 24
 Y of Bigelow, 29
 Ligamenta flava, 6
 Ligaments, of the bladder, 372
 of the larynx, 356
 of the liver, 340, 349
 of the ovary, 384
 peritoneal, 349
 utero-sacral, 384
 of the uterus, 349, 383
 Ligamentum arteriosum, 130
 denticulatum, 208
 nuchæ, 7
 patellæ, 33
 venosum, 341
 Limbus, 308
 Linea, alba, 108
 splendens, 208
 Lingula (of lung), 363
 Liver, ligaments, 340, 348
 lobes of, 340
 vessels, 342
 Lobe, frontal, 225
 occipital, 227

- Lobe, olfactory, 229
 • parietal, 226
 temporal, 228
- Locus cæruleus, 215
- Lungs, 361
- Lymphatics of the arm, 197
 of the axilla, 198
 of the bladder, 201
 of the breast, 199
 of the groin, 203
 of the head, 196
 • of the intestines, 200
 of the lungs, 202
 of the mesentery, 200
 of the neck, 196
 of the popliteal space, 203
 • of the prostate, 201
 of the stomach, 200
 of the thorax, 202
 of the uterus, 201
- Macula lutea, 316
 of the utricle, 307
- Malleus, 303
- Meatus, external auditory, 300
- Meatuses of the nose, 351
- Mediastinum of testis, 378
 of thorax, 365
- Medulla oblongata, 209
- Membrana tectoria, 9
 tympani, 301
- Membrane, atlanto-occipital,
 7
 crico-vocal, 357
 hyaloid, 317
 intercostal, 113
 interosseous (forearm), 23
 (leg), 37
 perineal, 119
 periodontal, 319
 quadrate, 357
 thyrohyoid, 357
- Membranes of the brain, 237
 of spinal cord, 208
- Meninges, 208, 237
- Menisci of knee, 35
- Mesentery, 348
- Mesocolon, pelvic, 349
 transverse, 349
- Midbrain, 219
- Modiolus of the cochlea, 306
 of face, 51
- Movement, bucket-handle, 13
 pump-handle, 13
- Muscle, abductor digiti minimi
 (foot), 85
 • hallucis, 104
 pollicis, brevis, 85
 longus, 83
 adductor brevis, 92
 • hallucis, 105
 longus, 92
 magnus, 92
 pollicis, 86
 anconeus, 75
 articularis genui, 91
 ary-epiglottic, 359
 arytenoid, transverse,
 359
 auricularis, 47
 biceps, 73
 femoris, 96
 of body wall (morpho-
 logy), 113
 brachialis, 74
 brachio-radialis, 80
 buccinator, 49
 bulbo-cavernosus, 375
 bulbo-spongiosus, 119
 ciliary, 314
 coccygeus, 117
 compressor naris, 47
 constrictor, inferior, 328
 constrictor, middle, 328
 superior, 328
 coraco-brachialis, 73
 corrugator, 46
 costalis, 63
 costo-cervicalis, 63
 cremaster, 109
 crico-arytenoid, lateral,
 359
 posterior, 358
 -pharyngeus, 328
 -thyroid, 356
 deltoid, 71
 depressor anguli oris, 49
 labii inferioris, 49
 diaphragm, 115
 digastric, 55
 ✓ dilator naris, 47
 pupillæ, 315
 effector spinæ, 61
 extensor carpi radialis

Muscle, brevis, 80 longus, 80
 ulnaris, 81
 digiti minimi, 81
 digitorum brevis, 103
 communis, 80
 longus (foot), 97
 hallucis longus, 97
 indicis, 84
 pollicis brevis, 83
 longus, 83
 flexor brevis hallucis, 105
 pollicis, 85
 carpi radialis, 76
 ulnaris, 77
 digiti minimi, 85
 brevis (foot), 106
 digitorum accessorius, 105
 brevis (foot), 101
 longus, 101
 profundus, 78
 sublimis (superficialis), 77
 hallucis brevis, 105
 longus, 101
 pollicis brevis, 85
 longus, 79
 gastrocnemius, 99
 gemellus inferior, 95
 superior, 95
 genio glossus, 321
 -hyoid, 56
 gluteus maximus, 93
 medius, 91
 minimus, 94
 gracilis, 93
 hyoglossus, 321
 iliacus, 88
 ilio-costalis, 63
 infraspinatus, 72
 intercostal, external, 113
 internal, 114
 intimi, 115
 interossei (hand) dorsal, 86
 palmar, 87
 (foot) dorsal, 106
 plantar, 106
 interspinales, 62
 intertransversales, 63
 intracostal, 115
 ischio-cavernosus, 119

Muscle, latissimus dorsi, 67
 levator anguli oris, 49
 ani, 117
 labii superioris, 48
 superioris
 alaeque nasi, 48
 palati, 324
 palpebrae superioris, 46
 scapulae, 68
 levatore costarum, 115
 lingual, 321
 longissimus, 64
 longus, capitis, 59
 cervicis, 59
 lumbrical (foot), 105
 (hand), 86
 masseter, 51
 multifidus, 63
 mylo-hyoid, 56
 oblique (abdominis) external, 108
 internal, 109
 (oculi) inferior, 318
 superior, 318
 obliquus capitis, inferior, 64
 superior, 64
 obturator externus, 91
 internus, 95
 occipito-frontalis, 47
 omo-hyoid, 57
 opponens minimi digiti, 85
 pollicis, 85
 orbicularis oculi, 45
 oris, 48
 palato-glossus, 321
 pharyngeus, 329
 palmaris brevis, 85
 longus, 76
 pectineus, 93
 pectoralis major, 69
 minor, 69
 peroneus brevis, 102
 longus, 102
 tertius, 98
 plantaris, 99
 platysma, 45
 popliteus, 100
 procerus, 48

Muscle, pronator quadratus,
 79
 teres, 76
 psoas major, 87, minor, 88
 pterygoid, lateral, 51
 medial, 52
 pubo-vaginalis, 117
 pyramidalis, 112
 piriformis, 95
 quadratus femoris, 95
 lumborum, 112
 quadriceps femoris, 89
 rectus abdominis, 111
 capitis anterior, 59
 lateralis, 59
 posterior, major,
 65
 minor, 65
 femoris, 90
 inferior, 318
 lateral, 318
 medial, 318
 superior, 318
 rhomboid major, 68
 minor, 68
 risorius, 51
 rotatores spinæ, 62
 sacrospinalis, 63
 salpyngo-pharyngeus, 330
 sartorius, 91
 scalenus anterior, 60
 medius, 60
 posterior, 60
 semimembranosus, 96
 semispinalis, 63
 semitendinosus, 96
 serratus anterior, 70
 posterior inferior, 61
 superior, 61
 soleus, 99
 sphincter ani externus,
 118
 internus, 118
 palato - pharyngeal,
 330
 pupillæ, 314
 urethræ, 120
 vaginæ, 119
 spinalis cervicis, 64
 thoracis, 64
 splenius capitis, 61
 cervicis, 61
 stapedius, 304

Muscle, sterno-costalis, 115
 -hyoid, 37
 -mastoid, 53
 -thyroid, 57
 stylo-glossus, 321
 -hyoid, 56
 -pharyngeus, 329
 subclavius, 70
 subcostals, 115
 subscapularis, 72
 supinator, 82
 supraspinatus, 72
 suspensory, of duodenum,
 334
 temporal, 51
 tensor, fasciæ latæ, 94
 palati, 324
 tympani, 304
 testes major, 72
 minor, 72
 thyro-arytenoid, 358
 -hyoid, 58
 tibialis anterior, 97
 posterior, 101
 transversus abdominis,
 110
 perinei, 119, 120
 thoracis, 115
 trapezius, 66
 triceps, 74
 vastus intermedius, 89
 lateralis, 89
 medialis, 90
 zygomaticus major, 49
 minor, 49
 Musculi papillares, 126
 pectinati, 123
 Musculus uvulæ, 324
 Nerve, abducent, 250
 accessory, 257
 alveolar, 145, 248
 auditory, 253, 308
 auricular, great, 261
 posterior, 252
 of vagus, 256
 auriculo-temporal, 248
 axillary, 266
 bronchial, 257
 buccal of 5th, 247
 of 7th, 242
 calcaneal, medial, 280

Nerve, cardiac inferior, 295
 middle, 295
 plexus, 297
 superior, 293
 from vagus, 257
 carotico-tympanic, 294
 carotid, 294
 cervical, first, 260, 261
 second, 260, 261
 transverse, 261
 chorda tympani, 249, 252
 ciliary, long, 244
 short, 244
 circumflex, 266
 coccygeal, 284
 cochlear, 253
 cutaneous, anterior, of
 neck, 261
 intermediate, 276
 lateral, lower (arm),
 268
 (thigh), 274
 upper (arm), 266
 cutaneous, medial of arm,
 266
 of forearm, 266
 of thigh, 276
 perforating, 278
 posterior, of arm, 269
 of forearm, 269
 posterior, of thigh,
 278
 dental, inferior, 248
 anterior superior, 245
 middle superior, 245
 posterior superior,
 245
 descending branch of
 hypoglossal, 259
 digastric, 252
 digital, median, 267
 plantar, 280
 radial, 269
 ulnar, 268
 dorsal cutaneous ulnar,
 268
 penis, 283
 dorsalis scapulae, 264
 ethmoidal, anterior, 243
 posterior, 243
 facial, 251
 femoral, 275

Nerve, frontal, 243
 gastric, 257
 genito-femoral, 274
 glosso-pharyngeal, 253
 gluteal, inferior, 278
 superior, 278
 hæmorrhoidal, inferior,
 283
 hypoglossal, 258
 ilio-hypogastric, 273
 inguinal, 274
 infra-orbital, 244
 infra-patellar, 276
 intercostal, 271
 intercosto-brachial, 272
 intermedius, 253
 interosseous, anterior, 267
 posterior, 269
 labial, 244, 283
 lacrimal, 242
 laryngeal, external, 256
 internal, 256, 358
 laryngeal, recurrent, 256,
 358
 superior, 256
 to latissimus dorsi, 266
 lingual, 249, 255
 lumbar, 273
 mandibular, 247, 253
 masseteric, 247
 maxillary, 244
 median, 267
 meningeal, 256
 mental, 249
 musculo-cutaneous (arm),
 267
 (leg), 282
 mylo-hyoid, 248
 nasal, 244, 245
 posterior superior,
 246
 naso-ciliary, 243
 -palatine, 246
 obturator, 274
 accessory, 275
 occipital, greater, 260
 lesser, 262
 third, 260
 oculomotor, 241
 œsophageal, 257
 olfactory, 240
 ophthalmic, 242

Nerve, optic, 240

- palatine, greater, 246
- lesser, 246
- palmar, cutaneous, 268
- palpebral, 245
- pectoral, lateral, 265
 - medial, 265
- perineal, 278, 283
- peroneal, common, 281
 - deep, 281
 - superficial, 282
- petrosal, deep, 246
 - external, 251
 - superficial, greater, 251
 - lesser, 254
- pharyngeal 247, 254, 256
- phrenic, 262
 - accessory, 265
- plantar, lateral, 281
- plantar, medial, 280
- popliteal, lateral, 281
 - medial, 279
- pterygoid, 246, 247, 248
- pudendal, 282
- radial, 269
- rhomboids, 264
- roots, spinal, 205
- sacral, 277
- saphenous, 276
- sciatic, 278
- scrotal, 283
- serratus, anterior, 205
- sinu-carotid, 255
- spheno-palatine, 245
- spinal, 259
- spinous, 247
- splanchnic, greater, 296
 - least, 296
 - lesser, 296
- splenic, 298
- stylo-hyoid, 252
- subclavius, 265
- subscapular, 266
- supraclavicular, 262
 - orbital, 243
 - scapular, 265
 - trochlear, 243
- sural, 280
 - communicating, 281
- sympathetic, abdomen, 297

Nerve, neck, 293

- pelvis, 299
 - thoracic, 296
 - temporal, deep, 247
 - of facial, 252
 - thoracic, 270
 - long, 265
 - thyro-hyoid, 259
 - thyroid, 295
 - tibial, 279
 - anterior, 281
 - posterior, 279
 - tonsillar, 255
 - trigeminal, 241
 - trochlear, 241
 - tympanic, 254
 - ulnar, 268
 - vaginal, 273
 - vagus, 255
 - vestibulo-cochlear, 253
 - zygomatic, 245
 - zygomatiko-facial, 245
 - temporal, 245
- Node, atrio-ventricular, 129
- lymph (see Glands lymph)
- sinu-atrial, 129
- Nodule, lentiform (nucis), 304
- Nose, cartilages, 351
- concha, 351
 - meatuses of, 351
- Notch, angular, 332
- Nuclei of cerebellum, 217
- Nucleus ambiguus, 215
- amygdaloid, 235
 - caudate, 235
 - dentate, 218
 - dorsal, 206
 - Edinger-Westphal, 211
 - hypoglossal, 215
 - lentiform, 235
 - pulposus, 215
 - red, 220
 - reticular, 220
 - salivatory, 215
 - of tractus solitarius, 216
 - vagal, 215
- Esophagus, 330
- arteries of, 133, 150
 - nerves of, 256
- Olive of medulla, 213

- Omentum, greater, 348
 lesser, 348
 Opening, sapranous, 89
 Opercula, 229
 Ora serrata, 316
 Orifice, atrio-ventriculu, 124,
 128
 Origin, common extensor, 80
 common flexor, 79
 of muscles, 44
 Ossicles, auditory, 303
 Os uteri externum, 383
 internum, 383
 Otoliths, 307
 Ovaries, 385
 lymphatics of, 201
 Pad, fat (Haversian), 28, 41
 Palate, hard, 323
 soft, 323
 Pancreas, 343
 Papilla, duodenal, 331
 lacrimal, 309
 Papillæ of the tongue, 320
 Paradox, action of, 44
 Parasympathetic outflow, 290
 Par-oophoron, 385
 Peduncles of the cerebellum,
 218
 of the cerebrum, 219
 Penis, 375
 Pericardium, 130
 Perilymph, 305
 Peritoneum, 344
 of female pelvis, 345, 349
 of male pelvis, 344
 Pes hippocampi, 232
 Pharynx, 327
 Pia mater of the brain, 238
 of the cord, 208
 Pillars of the fornix, 233
 Pineal body, 22
 Plac, neuro-vascular, 110
 Pleura, 361
 Plexus, aortic, 299
 brachial, 263
 cardiac, deep, 297
 superficial, 297
 carotid, 294
 cavernous, 294
 cervical, 261
 choroid, 234
 coeliac, 298
 gastric, superior, 298
 hepatic, 298
 hypogastric, 299
 lumbar, 273
 mesenteric, inferior, 299
 superior, 298
 oesophageal, 255
 patellar, 276
 pelvic, 299
 pharyngeal, 293
 phrenic, 298
 prostatic, 299
 pterygoid, 183
 pulmonary, 257
 rectal, 299
 renal, 298
 sacral, 277
 splenic, 298
 subsartorial, 276
 suprarenal, 298
 testicular, 298
 tympanic, 254
 vertebral, 189
 vesical, 299
 vesico-prostatic, 194
 Plica semilunaris, 309
 Pons, 216
 Porta hepatis, 340
 Pouch, recto-uterine (Doug-
 las), 345
 Precuneus, 227
 Prepuce, 375
 of clitoris, 381
 Process, caudate, 341
 ciliary, 314
 Processus cochleariformis, 303
 vaginalis, 384
 Promontory, 301
 Pronation, 23
 Prostate gland, 374
 Pulvinar, 221
 Punctum lacrimale, 309
 Putamen, 235
 Pylorus, 332
 Pyramids, decussation of, 214
 of kidney, 370
 of the medulla, 214
 of the tympanum, 302
 Raphé, mylo-hyoid, 56

- Raphé, palpebral (lateral), 45
 pharyngeal, 328
 pterygo-mandibular, 50
 of the scrotum, 376
 Recess, epitympanic, 301
 pharyngeal, 328
 Rectum, 337
 Rete testis, 378
 Retina, 316
 Retinacula, hip-joint, 29
 peroneal, 103
 Retinaculum, extensor (leg), 98
 (wrist), 75, 84
 flexor (leg), 102
 Retinaculum flexor (wrist), 75
 Rhinencephalon, 229
 Ridge, Passavant's, 330
 Rima of the glottis, 358
 Ring, inguinal, deep, 111
 superficial, 109
 Root of the lung, 364
 Rostrum of corpus callosum, 230

 Sac, lacrimal, 310
 Saccule of the ear, 307
 of the larynx, 358
 Scala tympani, 306
 vestibuli, 307
 Sclera of the eye, 311
 Scrotum, 376
 Septum, atrial, 122
 intermuscular, thigh, 89
 lucidum, 233
 nasi, 351
 of the penis, 375
 posterior, of cord, 206
 of the scrotum, 377
 of the tongue, 323
 Sheath, femoral, 111
 of the rectus, 111
 synovial (hand), 78
 Sinus, aortic, 132
 basilar, 181
 cavernous, 181
 coronary, 128
 of dura mater, 180
 intercavernous, 181
 occipital, 180
 paranasal, 352
 of pericardium, 130
 Sinus, petrosal, inferior, 181
 superior, 181
 sagittal, inferior, 180
 superior, 180
 sigmoid, 180
 sphenoparietal, 181
 straight, of the skull, 180
 transverse, 180
 venosus scleræ, 312
 Snuff-box (anatomical), 84
 Space, quadrilateral, 73
 subarachnoid, 238
 subdural, 238
 triangular, 73
 Spaces (palmar), 84
 Spleen, 387
 Splenium, 230
 Stapes, 304
 Stomach, 331
 Striae, medullary, 215
 semicircularis, 236
 Substantia gelatinosa, 206
 nigra, 219
 Sulci of brain, 224
 Sulcus, calcarine, 228
 central, 224
 cinguli, 224
 circular, 229
 collateral, 225
 hippocampal, 230
 intraparietal, 226
 lateral, 224
 oculomotor, 219
 orbital, 225
 parieto-occipital, 225
 postcentral, 226
 posterior median, of cord, 206
 temporal, 228
 terminalis, 124
 Supination, 23
 Suprarenal gland, 389
 Symphysis pubis, 28
 Synchronosis, 2
 System, conducting of heart, 129

 Tæniæ coli, 316
 Tapetum, 230
 Tarsi, 310
 Teeth, 319
 Tegmentum, 220

Tela choroidea, 234
 Tentorium cerebelli, 237
 Testes, 377
 Thalami, 221
 Thymus gland, 389
 Thyroid gland, 388
 Tongue, 320
 lymph drainage, 197
 Tonsil, 325
 lingual, 321
 Trabeculae carneae, 125
 Trachea, 360
 Tract, cerebro-spinal, 213
 Tract, ilio-tibial, 89
 optic, 240
 solitarius, 216
 spino-cerebellar, 207
 Tractus spiralis foraminosus, 309
 Tree, bronchial, 364
 Triangle, femoral, 91
 hypoglossal, 215
 lumbar, 109
 suboccipital, 65
 vagal, 215
 Trigone of bladder, 373
 Trigonum habenulae, 221
 Trunk, lumbosacral, 273
 pulmonary, 130
 sympathetic, 292
 thyro-cervical, 149
 Tube, auditory, 302
 pharyngo-tympanic, 302
 uterine, 384
 Tuber cinereum, 222
 Tubercle, cuneate, 212
 gracile, 211
 intervenous, 124
 Tubules, efferent, 379
 seminiferous, 379
 Tunica albuginea testis, 378
 vaginalis, 378
 Tympanum, 301
 Urachus, 372
 Ureter, 370
 Urethra, female, 382
 male, 376
 Uterus, 382
 ligaments of, 349, 383
 lymphatics of, 201
 Utricle of the ear, 307

Utricle, prostatic, 376
 Vulva of bladder, 373
 palati, 323
 Vagina, 382
 Vallecule, cerebelli, 217
 of tongue, 320
 Valve, anal, 338
 aortic, 127
 coronary, 128
 ileo-caecal, 336
 mitral, 127
 pulmonary, 127
 tricuspid, 126
 Vas deferens, 379
 Vein, anastomotic, posterior, 179
 superior, 179
 auricular, posterior, 184
 axillary, 186
 azygos, 188
 basal, 179
 basilic, 186
 basi-vertebral, 189
 brachio-cephalic, 187
 bronchial, 189
 cardiac, anterior, 129
 great, 128
 middle, 128
 small, 128
 cephalic, 186
 cerebellar, 180
 cerebral, 179
 great, 179
 internal, 179, 235
 choroid, 179
 colic, 191
 diploic, 181
 dorsal, of the penis, 375
 emissary, 181
 epigastric, inferior, 193
 superficial, 192
 facial, 181
 femoral, 193
 frontal, 181
 gastric, 191
 gastro-epiploic, 191
 gluteal, 194
 hepatic, 340, 343
 iliac, common, 194
 external, 193
 internal, 193

- Ven, ileo-colic, 191
 infra-orbital, 183
 innominate, 187
 intercostal, left, 188
 right, 188
 jugular, anterior, 184
 external, 184
 internal, 184
 jugulo-cephalic, 186
 labial, 182
 lingual, 185
 lumbar, 189
 mammary, internal, 187
 mastoid emissary, 181
 maxillary, 183
 median, of the arm, 185
 basilic, 186
 cephalic, 186
 mesenteric, inferior, 191
 superior, 191
 nasal, 182
 occipital, 184
 ophthalmic, 180
 ovarian, 190
 palmar, 186
 pancreatic, 314
 penis, 375
 pharyngeal, 185
 popliteal, 193
 portal, 190, 343
 profunda of the thigh, 193
 pudendal, 194
 pulmonary, 191
 radial, 185
 rectal, 192, 194
 renal, 190
 retromandibular, 184
 saphenous, long, 192
 short, 193
 spinal, 190
 splenic, 191
- Ven, striate, 179
 subclavian, 187
 submental, 184
 supra-orbital, 182
 -renal, 389
 temporal, 182
 testicular, 190
 thyroid, inferior, 187
 middle, 185
 superior, 185
 tibial, anterior, 193
 posterior, 193
 umbilical (obliterate
 319
 uterine, 194
 vaginal, 194
 vertebral, 185
 veinal, 194
- Velum, medullary, 210
- Vena azygos, 188
 cava, inferior, 189
- Vena, cava, superior, 188
 hemazygos, 188
- Ventricles of the brain, four
 214
 lateral, 231
 third, 220
 of the heart, left, 127
 right, 125
- Vermis of cerebellum, 217
- Vesiculæ seminales, 380
- Vestibule of the ear, 305
 of the vulva, 382
- Vincula brevia, 79
 longa, 79
- Vitreous body, 310
- Vulva, 381
- Zona, orbicularis, 29
- Zonule, ciliary 317

